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ABSTRACT

This report provides quantitative data to assist in decisionmaking while United States science and technology is in transition. This 1998 report features new data and analyses. In addition to enhanced international comparisons and a chapter on the significance of information technologies, features of this report include improved international performance indicators of precollege science and mathematics education, curricula, and teacher preparation; enhanced coverage of the situation of recent graduates and postdoctoral scientists and engineers; and venture capital indicators. The report overview is organized around four themes that encapsulate significant trends in the transition into the 21st century which include increasing globalization, greater emphasis on education and training, structural and priority changes, and the increasing impact of science and technology on daily lives. (DDR)

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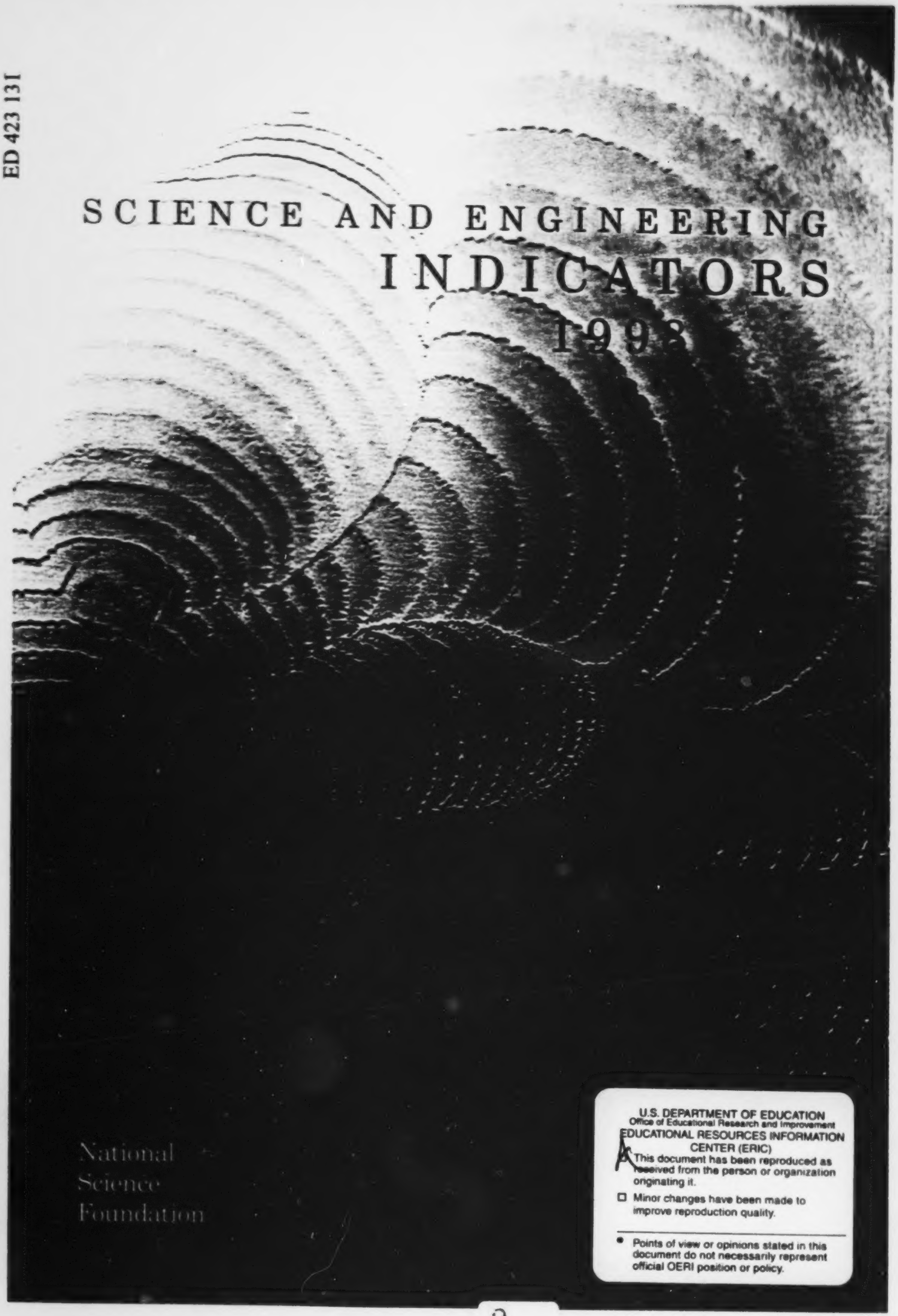

SCIENCE AND ENGINEERING INDICATORS 1998

National Science Board

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1998

NSF **NATIONAL SCIENCE BOARD**

The Cover

Felice Frankel, MIT Artist in Residence and Research Scientist, believes that bringing an aesthetic component to scientific imagery is one way of making science more accessible. Her photograph of Proteus colonies growing in patterns on a petri dish captures part of James Shapiro's research at the Department of Biochemistry and Molecular Biology, University of Chicago. The scale reference for the image is 5 cm.

Frankel collaborates with investigators in numerous disciplines, creating images that have appeared on the covers and pages of various journals. Her most recent collaboration is the book *On the Surface of Things* (Chronicle Books), with text by George M. Whitesides, Mallinckrodt Professor of Chemistry, Harvard University.

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Letter of Transmittal

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NATIONAL SCIENCE BOARD
4201 Wilson Boulevard
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February 26, 1998

The Honorable William J. Clinton
The President of the United States
The White House
Washington, DC 20500

Dear Mr. President:

It is my honor to transmit to you, and through you to the Congress, the thirteenth in the series of biennial Science Indicators reports, *Science and Engineering Indicators – 1998*. The National Science Board submits this report in accordance with Sec. 4(j)(1) of the National Science Foundation Act of 1950, as amended.

These reports are designed to provide a broad base of quantitative information about U.S. science, engineering, and technology for the use of public and private policymakers in their decisions about these activities.

Investments in basic research, advanced technology, and science and engineering education are critical to the achievement of our national economic and social goals of improving health, welfare, economic competitiveness, and national security. The quantitative analyses in this report provide information on a variety of critical trends and issues as we prepare to enter the 21st century.

The report presents information on science and mathematics education from the precollege level, through graduate school, and beyond; and also presents information on public attitudes and understanding of science and engineering. It analyzes science and engineering activities in the United States and provides valuable comparative information on science and technology in other countries. One of the important new features of the report is a chapter on the "Economic and Social Significance of Information Technologies." I should also note that the entire report will be available on the World Wide Web.

I hope that you, your Administration, and the Congress will find this report useful as you discuss and determine the policies and priorities for the Nation.

Respectfully yours,

Richard N. Zare

Richard N. Zare
Chairman

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The National Science Board extends its appreciation to the staff of the National Science Foundation for preparing this report.

Organizational responsibility for the volume was assigned to the Directorate for Social, Behavioral and Economic Sciences, Bennett I. Bertenthal, Assistant Director.

Primary responsibility for the production of the volume was assigned to the Science and Engineering Indicators Program, under the direction of Jennifer Sue Bond of the Division of Science Resources Studies (SRS), Jeanne E. Griffith, Director. The Directorate for Education and Human Resources (EHR) also contributed to portions of the report.

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Introduction: The Past Is Prologue

Maintaining a Tradition of Excellence and Innovation

For more than a quarter of a century, the National Science Board's *Science & Engineering Indicators* report series has been a chronicler of key trends in science and engineering research and education. As the United States begins the transition into the 21st century and into a knowledge-based economy, it is worthwhile to examine the significant changes in the science and technology (S&T) enterprise that characterize the current period. Many of the issues faced at the time of the Board's first report, *Science Indicators – 1972*, endure. Also, important aspects of the future will be at least partially determined by the S&T resources—both human and financial—in which the Nation has already invested.

An analysis of historical trends is possible due to the foresight of science policy leaders in the past. The collection and analysis of quantitative information as a basis for policy and decisionmaking was an integral component of the National Science Foundation's (NSF's) mandate from the outset. In preparing NSF's first full-year budget for fiscal year 1952, the National Science Board allocated $1 million of its approximately $13.5 million request for a survey of the Federal Government's financing of research and development (R&D). In 1953-54, NSF extended its surveys beyond the Federal Government to encompass research support and performance in industry, colleges and universities, and other organizations. At about the same time, it initiated the first in a series of human resource surveys.

"Through these studies," as NSF's 1957 annual report emphasized, "the Foundation has provided a new kind of measurement of national economic strength." This quote from a document published over four decades ago is as appropriate today as it was then. Many of the indicators that were developed at that time are still viewed as essential ways of measuring national S&T capabilities and economic strength. As times change, the need for additional data and indicators has evolved, along with the need for greater elaboration and disaggregation of many of the previous data trends. This information and analyses enable a better understanding of the various characteristics of the S&T enterprise, including who the various participants are, patterns of collaboration, and impacts on the broader society.

The 1957 annual report, which included a chapter summarizing NSF's survey activities and highlighting future survey plans, stressed the centrality of this work to the agency's mission. In fulfilling its statutory responsibility to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences, the National Science Foundation developed and has continued its surveys of the U.S. R&D effort in various sectors of the economy. These studies and surveys provide a solid basis for analyses, conclusions, and recommendations concerning S&T resources.

Responding to Expanding User Needs

The National Science Foundation Act of 1950, as amended, states that the Board is responsible for rendering to the President for submission to Congress in each even-numbered year a report on indicators of the state of science and engineering in the United States (Sec. 4 [j][1]). The current issue, *Science & Engineering Indicators – 1998*, is the 13th in the biennial series. This important national and international data resource is part of the Board's larger responsibility in the area of national science and technology policy.

The Act further authorizes the Board to advise the President and Congress on matters of science and engineering policy (Sec. 4 [j][2]). In accord with this broader obligation, the Board has determined to prepare a series of occasional papers commenting on selected trends in the *Indicators* report to focus attention on issues of particular current and long-term concern regarding the Nation's science and engineering enterprise.

Governments at all levels and nongovernmental organizations in the United States as well as in many other countries are increasingly concerned with accountability and benchmarking activities. With the advent of the Government Performance and Results Act (GPRA), the development of reliable output and impact indicators for inclusion in the *Science & Engineering Indicators* report series has become even more important. *Science & Engineering Indicators – 1998* provides data and information that can be useful as a general framework or source of complementary information as various organizations develop their own specific performance indicators.

The conceptualization of new types of quantitative information to characterize emerging aspects of the science and engineering enterprise and their impacts has had a significant influence on the evolution of indicators methodology itself. *Science & Engineering Indicators – 1998* continues this tradition with a new chapter titled "Economic and Social Significance of Information Technologies." There is an increasing need to understand and communicate more effectively and efficiently the contributions and outcomes of science and technology. Measurement of the economic and social impacts of S&T is a special challenge particularly for rapidly developing areas epitomized by information technologies. The Board believes that this new chapter, which addresses both positive and negative aspects of information technologies, makes a significant contribution toward synthesizing and crystallizing what is currently known about this important topic.

Beginning in the late 1950s, NSF's annual reports devoted increasing attention to the international context of U.S. science and engineering, particularly following the launching of Sputnik I by the Soviet Union in October 1957. Reflecting the importance of comparative international information, *Science Indicators – 1972* included data on R&D expenditures of several major foreign countries. Coverage of international topics has been enhanced with each succeeding edition of the report, as has its international readership. Noting the increase in the globalization of science and technology and the increased interdependence of the world's economies, the Board decided to make international comparisons and global trends a major theme of the *Science & Engineering Indicators – 1998* report. The growing availability of internationally comparable data is—in large measure—the result of close working relationships developed over many years between NSF staff and their counterparts in other countries who are also engaged in the collection and analysis of indicators data. Several multinational organizations also contribute substantially to making such data available. These include the Organisation for Economic Co-operation and Development (OECD), the United Nations Economic, Scientific, and Cultural Organization (UNESCO), the European Union (EU), the Pacific Economic Cooperation Council (PECC), the Asian Pacific Economic Cooperation (APEC), the InterAmerican InterIberian Science and Technology Network (RICYT), and the Organization of American States (OAS).

In recognition of the increasing attention worldwide to the importance of developing S&T indicators, as well as NSF's international leadership in this effort, NSF and OECD organized an international workshop on the Uses of Science and Technology Indicators for Decisionmaking and Priority Setting; this was held at NSF headquarters from September 7-9, 1997. Claudia Mitchell-Kernan, Chairman of the Science & Engineering Indicators Subcommittee, represented the National Science Board as a co-host of the meeting and stressed the growing importance of international comparisons. The representatives from 28 countries and six international organizations who participated in the event strongly concurred.

Today, the need for quantitative data to assist in decisionmaking is even stronger than it was when the Board first began this effort. The U.S. science and technology enterprise is in transition. The country is changing its priorities for R&D investment and faces budgetary constraints in many sectors. Additionally, the United States—and the rest of the world—is part of an increasingly global economy. Science and engineering activities have always had a global dimension, but this is now intensifying. *Science & Engineering Indicators – 1998* not only emphasizes international comparisons, but also provides data and analyses related to all of the above important topics.

With the growth of the science and engineering enterprise over the past decades and of public recognition of its importance to economic and social well-being, the audience for the *Science & Engineering Indicators* reports and the need for new data and analyses have expanded. To make these data more accessible to this growing audience, the entire report is now available in electronic format (<<http://www.nsf.gov/sbe/srs/stats.htm>>) as well as in hard copy.

Additional New Features of This Report

In the tradition of previous reports, *Science & Engineering Indicators – 1998* contains a number of new features and indicators. In addition to enhanced international comparisons and a new chapter on the significance of information technologies, these new features include the following:

- improved international performance indicators of precollege science and mathematics education, curricula, and teacher preparation;
- increased attention to and new indicators of international S&T mobility, such as foreign participation in the S&T activities of the Nation, international engineering programs in the United States, and the reverse flow of scientists and engineers to Asia;
- enhanced coverage of the situation of recent graduates and postdoctoral scientists and engineers;
- coverage of the restructuring of the defense industry and its impact on the Nation's S&T enterprise;
- enhanced and new indicators of intersectoral and international collaborations/partnerships;
- expanded coverage of the service sector;
- new venture capital indicators;
- new indicators of Internet and World Wide Web use;
- indicators of the impacts of information technologies on science, mathematics, and engineering education, including some attention to distance learning in higher education;
- potential future requirements for information technology employment; and
- analyses of access to the latest information technologies and their potential impact on participation in science and mathematics careers.

Another new feature of *Science & Engineering Indicators – 1998* is the inclusion of several reflections on future pressures and possible trends, coupled with the identification of a number of important data and information gaps that deserve continuing attention.

The report Overview is organized around four cross-cutting themes that encapsulate significant trends in the transition into the 21st century. Taken together, these trends exemplify both the condition of the science and engineering enterprise in the United States and the links between science and engineering activity and U.S. society more broadly as the country prepares for a new century. These trends are:

- **Increasing globalization of science, technology, and the economy.** Other countries besides the United States are investing in financial and human resources for science and technology, recognizing that such investments are essential underpinnings for social and economic well-being in the global economy. Individual scientists and engineers, industrial firms, and academic institutions are taking advantage of the increasingly international character of S&T, as witnessed by the enhanced international mobility of the S&T workforce, international coauthorship of scientific publications, the development of international industrial alliances, and the global flow of technological know-how.
- **Greater emphasis on science and engineering education and training.** Many countries, including the United States, recognize the importance of providing an excellent education to their population in a global, knowledge-based economy. At the professional level, universities in the United States and elsewhere face the challenge of introducing greater flexibility and breadth into their curricula so as to improve the employment prospects of their students at both the undergraduate and graduate levels. More broadly, the Nation as a whole faces the challenge of ensuring that its diverse workforce will possess sufficient technological literacy, and its citizenry sufficient knowledge and understanding of S&T and its socioeconomic impacts, to address the requirements of the new century.
- **Structural and priority changes in the science and engineering enterprise.** The decreasing involvement of the Federal Government relative to private industry in providing financial support for the Nation's R&D effort, evident since the beginning of the decade, persists. The federal role remains essential, however, in the support of basic research in the academic sector and in the integrally linked education of the country's science and engineering workforce. Even as the role of industry in supporting R&D has become more prominent, the structure of research in industry itself is changing, as is evident from the increasing prominence of R&D in the service industries. Industrial R&D support remains most heavily concentrated in applied research and development, as opposed to basic research. That private industry recognizes the importance of U.S. colleges and universities to the national enterprise is evident from the increasing links between the industrial and academic research sectors.
- **Increasing impact of science and technology on our daily lives.** The impact of S&T on our daily lives is profound—however difficult to track or quantify. The changes brought about in the workplace, schools, and homes by information technologies may be the most obvious case in point. Data characterizing many of the more important effects are presented in chapter 8 of this report, "Economic and Social Implications of Information Technologies."

None of the cross-cutting themes identified as exemplary of the U.S. science and engineering enterprise in this, the penultimate edition of *Science & Engineering Indicators* in the 20th century, is particularly novel. Indeed, these themes have been apparent—at least in retrospect—in the results of the surveys that NSF has been carrying out since the 1950s. These themes will no doubt continue to be important in the year 2000 and beyond.

A Continuing Responsibility

A decade ago, it would have been all but impossible to predict, in any detail, the ubiquitousness of information technologies in our lives. By the same token, it is all but impossible to predict the effect of current S&T activity on our daily lives at the end of the first decade of the new century. One of the few predictions that the Board *can* make with any certainty is that the four cross-cutting themes described above will remain important after the turn of the century. It is also apparent that no ultimate solutions will have been found to the many important S&T-related issues that the Nation's decisionmakers and citizenry will face. Nevertheless, the thrill of discovery, the quest for knowledge, and the need to apply such knowledge to human problems will remain.

The *Science & Engineering Indicators* reports are intended to provide the factual information on S&T resources needed by policymakers in government, industry, and academia in weighing policy options. The National Science Board has long provided high-quality quantitative information relevant to S&T policy issues through its biennial *Science & Engineering Indicators* reports. The Board considers these reports to be a sturdy basis on which to build. It routinely revisits their format, the data and indicators they contain, and the implications of the trends identified. Interactions with the scientific community and the public provide opportunities to examine the implications of the data and anticipate what data and indicators will be needed in the future. The Board welcomes the opportunity to develop new and refined indicators to document the evolution of the U.S.—and global—science and engineering enterprise in the final years of the 20th century and beyond.

Overview: Science and Technology in Transition to the 21st Century

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"The force of scientific and technological innovation is helping to fuel and shape that new economy, but its impact goes beyond. These investments have surely paid off in higher paying jobs, better health care, stronger national security, and improved quality of life for all Americans. They are critical to America's ability to maintain our leadership in cutting-edge industries that will power the global economy of the new century."

PRESIDENT WILLIAM J. CLINTON

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Science, technology, and economies are becoming increasingly global. This is one of the major trends characterizing the transition into the 21st century. U.S. investments in science and technology (S&T) should be viewed in a global context. The United States and many other countries are investing in S&T capabilities, with both financial support and human resource development. Science & engineering (S&E) students and personnel are internationally mobile. Scientific and technological collaboration and alliances are increasing in both academia and industry. The most effective form of S&T transfer is "people embodied," but technological know-how is also transferred through direct investment, patenting activity, the sale of intellectual property, and trade in technology-embodied products. The following highlights demonstrate the globalization of science, engineering, technology, and the economy in terms of growth in worldwide S&T investments and increased international interactions.

Many countries are investing in science and technology as a key economic strategy.

- The U.S. economy continues to rank as the world's largest, and the United States (all sectors combined) also spends the largest amount for research and development (R&D). Similarly, most other industrialized and developing countries are investing in R&D. European countries have long done so, but now countries in Asia and the Americas are also putting special emphasis on increasing both human and financial investment in S&T.
- Expenditures on R&D performed in the United States exceeded $200 billion for the first time in 1997. The United States accounts for about 44 percent of the industrial world's R&D investment and almost as much as the other G-7 countries (Japan, Germany, the United Kingdom, France, Italy, and Canada) combined. In civilian R&D, however, the expenditures of these six countries totaled 18 percent more than nondefense R&D spending in the United States.

S&E education is increasing globally.

- Many countries have invested in training scientists and engineers. From the mid-1980s to the mid-1990s, the number of degrees in higher education in science and engineering increased rapidly in Asia and Europe. Trend data from selected Asian countries show great increases in the number of first university degrees in science and engineering fields for China, India, Japan, South Korea, Singapore, and Taiwan. Between 1975 and 1995, the total number of degrees in the natural sciences earned by students from these countries doubled; those in engineering almost tripled.

- From 1975 to 1992, the Western European countries collectively more than doubled their annual production of first university degrees in science and engineering. This increase in S&E degree production occurred despite a declining pool of college-age students in Europe. Participation rates in S&E degrees increased to more than offset the declining population.
- Europe leads the United States and Asia in S&E doctoral degree production. In 1995, doctoral degrees awarded in S&E fields by Western and Eastern European (including Russia) institutions totaled 45,647—about 60 percent higher than the North American level and almost three times as many as the number recorded for Asian countries.
- The global diffusion of S&E education has implications for the U.S. higher education system. Other countries' increasing capacity to educate students in advanced levels of science and engineering may be one reason for the decline in foreign student enrollment in U.S. engineering programs. Additionally, the continuing expansion of global capacity for S&E education may affect all nations, since it indicates an increasing potential for technological and economic development worldwide.

The S&T workforce is becoming more global.

- The number of scientists and engineers engaged in research and development has increased in many countries. The U.S. share of the total numbers of R&D scientists and engineers in the G-7 has fallen slightly from 48 percent in 1981 to 45 percent in 1993. Japan had 80 scientists and engineers engaged in R&D for every 10,000 persons in the labor force in 1993, compared with 74 for the United States.
- In the past decade, foreign students have accounted for the large growth in S&E doctoral degrees in U.S. universities. For the period 1992-96, the percentage of foreign doctoral recipients planning to remain in the United States increased: more than 68 percent planned to locate in the United States, and nearly 44 percent had firm offers to do so. Stay rates differ considerably by nationality. In 1996, more than half (57 to 59 percent) of S&E doctoral recipients from China and India receiving their degrees from a U.S. institution had firm plans to stay. A smaller percentage of those from South Korea and Taiwan (24 and 28 percent, respectively) accepted employment offers in the United States.
- International mobility is a characteristic of postdoctoral researchers. From 1990 to 1994, U.S. universities provided slightly more than half of their postdoctoral appointments to non-U.S. citizens. Another indicator of international mobility is the proportion of foreign-born faculty in U.S. higher education. In 1993, 37 percent of U.S. engineering professors and 27 percent

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"Science and art belong to the whole
world and before them vanish
the barriers of nationality."

JOHANN WOLFGANG VON GOETHE

❖

of U.S. mathematics and computer science professors were foreign-born. These faculty members are mainly from Asia and Europe, with the largest numbers coming from India, China, the United Kingdom, Taiwan, Canada, and South Korea.

- In 1993, almost a quarter (23 percent) of doctoral scientists and engineers in the United States were foreign-born. More than a third of these (34 percent) received their S&E doctorates from foreign institutions. In general, the percentage of immigrants is highest in fields with very good labor market conditions, such as engineering and computer sciences. The highest proportion of foreign-born holders of doctorates was in civil engineering (51 percent); the lowest was in psychology (9 percent).
- Some U.S. doctorate recipients go abroad. A lower-bound estimate of U.S.-born Ph.D. graduates residing abroad in 1995 is 13,900 (3.3 percent of the total). If those with U.S. citizenship or permanent residency at the time of their degrees are included, this rises to 19,600 (4.1 percent of the total).

Scientific publications are increasingly international in character.

- Since 1981, the overall number of articles published in a set of the world's influential S&T journals rose by almost 20 percent, compared with a rise of 8 percent in articles attributed to U.S. authors. This increase coincided with the strengthening of S&T capabilities in several world regions. Europe increased its share of published output from 32 percent in 1981 to 35 percent in 1995, reaching a higher share than that of the United States. Asia's share rose from 11 to 15 percent over the period.
- International collaboration on scientific publications is increasing, reflecting the globalization of science. In 1995, half of the articles in a set of journals covered by the Science Citation Index had multiple authors, and almost 30 percent of these involved international collaboration. A steadily growing fraction of most nations' papers involved coauthors from different nations. From 1981 to 1995, while article output grew by 20 percent, the number of articles with multiple authors rose by 80 percent, and the number with international coauthors by 200 percent. These trends affected all fields.
- For almost every nation with strong international coauthorship ties, the number of articles involving a U.S. author rose strongly between 1981 and 1995. Nevertheless, during this same period, many nations broadened the reach of their international collaborations, particularly within

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"Every great advance
in science has issued from
a new audacity of imagination."

JOHN DEWEY

⁂

geographical regions, causing a drop in the U.S. share of the world's internationally coauthored articles. In the Asian region, collaboration particularly involved China and the newly developing industrial countries.

- Citation patterns also mirror the global nature of the scientific enterprise, as researchers everywhere extensively use and cite research findings from around the world. U.S. scientific and technical articles as a whole are cited by researchers in virtually all mature scientific nations in proportions greater than the U.S. share of world output in chemistry, physics, biomedical research, and clinical medicine. U.S. articles in the remaining fields tend to be cited at or slightly below the U.S. share of world output.

Industrial firms are developing international alliances.

- Industrial firms are using global research partnerships as a means of strengthening core competencies and expanding into technology fields that are crucial to maintaining market share. Since the mid-1980s, companies worldwide have entered into over 4,000 known multi-firm alliances involving strategic technologies. More than one-third of these were between U.S. firms and European or Japanese firms. Most of the alliances were created to develop and share information technologies.

Foreign patenting activity demonstrates the global nature of technology.

- Foreign patenting in the United States is also strong and highly concentrated by country of inventor. Five countries—Japan, Germany, France, the United Kingdom, and Canada—accounted for 80 percent of foreign-origin U.S. patents. Several newly industrialized economies, notably Taiwan and South Korea, dramatically increased their patent activity in the late 1980s and continue to do so.
- Americans successfully patent their inventions around the world. U.S. inventors received more patents than other foreign inventors in neighboring countries—Canada and Mexico—and in distant markets such as Japan, Hong Kong, Brazil, India, Malaysia, and Thailand.

Trends in royalties and fees indicate global flows of technological know-how.

- The United States is a net exporter of technological know-how; royalties and fees received from foreign firms have averaged three times those paid to foreigners by U.S. firms for access to their technology. Japan is the largest consumer of U.S. technology sold as intellectual property, and South Korea is the second largest.

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"The world is changing more quickly
than ever. Each of us sees the speed
and force of those changes around us
every day, in ways we perceive
as wondrous, elegant and profound –
even sometimes, a little overwhelming."

RICHARD N. ZARE
CHAIRMAN
NATIONAL SCIENCE BOARD

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Foreign direct investments in R&D are increasing and demonstrate S&T globalization

- Substantial investment in R&D is made by U.S. firms abroad as well as foreign firms in the United States. From 1985 to 1995, U.S. firms increased their R&D investment abroad three times faster than their company-funded R&D performed domestically.
- R&D funding in the United States by foreign companies grew an average of 12.5 percent per year from 1987 to 1995, even after adjusting for inflation. Foreign-sourced R&D performed in the United States is now roughly equivalent to U.S. companies' R&D investments abroad. More than 670 foreign-owned R&D facilities are located in the United States.
- Most of the foreign international investment in R&D flowing into the United States is from Europe and Japan and is concentrated in the drugs and medicines, industrial chemicals, and electrical equipment industries.

International trade in technology products is another indicator of S&T globalization.

- The United States continues to be the leading producer of high-tech products, responsible for about one-third of the world's production of such products. During the 1980s, Japan rapidly enhanced its stature in high-tech fields, but by 1995, U.S. high-tech industries regained world market share lost during the previous decade.
- Between 1990 and 1995, three of the four science-based industries in the United States that form the high-tech group—computers, pharmaceuticals, and communications equipment—gained world market share. Aerospace was the only U.S. high-tech industry to lose market share in the 1990s. The U.S. trade surplus in software technology doubled, and aerospace technologies produced large—albeit declining—trade surpluses for the United States.

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> *"A nation which depends upon others*
> *for its basic scientific knowledge*
> *will be slow in its industrial progress*
> *and weak in its competitive position*
> *in world trade, regardless*
> *of its mechanical skill."*
>
> VANNEVAR BUSH

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Many countries are emphasizing science, math, and engineering education as essential to achieving economic and societal goals both now and in the 21st century. There is an increasing realization of the importance of education and knowledge to economic growth. Such education is seen as important not only for researchers but also for a diverse, technologically literate workforce and for an educated and informed citizenry. Examining, updating, and improving the U.S. education system from K-12 through to graduate school is a major national priority as we enter the next century. Concerns have been expressed regarding the employment prospects of science and engineering graduates, and universities are examining ways to make graduate education broader, more flexible, and relevant to present and future economic demands. Current issues include the role of the Federal Government in funding graduate education, the further integration of research and education, and the importance of attracting and retaining students from all backgrounds into science and engineering fields. The following highlights provide some information on these topics.

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> *"The path to any nation's scientific and technological capability is an early, strong, and continuous math and science education for each and every student. The earlier it begins and the longer it lasts, the better for the individual and the nation."*
>
> NEAL LANE
> DIRECTOR
> NATIONAL SCIENCE FOUNDATION

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Progress has been made in precollegiate math and science education, but more needs to be done—especially in mathematics.

- In national assessments of math and science learning, students are performing as well as, if not better than, the students of 25 years ago. Nine-year-olds and 13-year-olds are scoring higher on mathematics and science tests than they did in 1973, while performance of 17-year-olds has remained about the same.
- In the United States, there is little difference in the mathematics and science proficiency of girls compared with boys on national assessments of education progress. As of 1996, however, large differences remain at all grade levels in the achievement scores of black and Hispanic students as compared with whites and Asians/Pacific Islanders. Native Americans generally scored closer to the national average than did blacks or Hispanics, but lower than whites.
- In a 1995 international comparative study on mathematics and science achievement, U.S. students performed comparatively better in science than in mathematics and better at the fourth grade level than at the eighth grade level.
- U.S. fourth graders were significantly surpassed in science performance only by students in South Korea. Students in Japan, the Netherlands, Australia and Austria also performed well at this level. U.S. eighth grade students scored just above the international average in science, scoring lower than students from Singapore, South Korea, Japan, and the Czech Republic.

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"Statistical thinking will one day
be as necessary for efficient citizenship
as the ability to read and write."

H.G. Wells

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- Unlike in science, performance in mathematics at the fourth grade level in a 1995 international test showed U.S. students behind those of Singapore, South Korea, Japan, and Hong Kong. U.S. eighth graders answered just over half of the items on the mathematics assessment correctly and scored below the international average. Eighth grade students in Singapore, Japan, South Korea, Hong Kong, Flemish-speaking Belgium, and the Czech Republic performed the best.
- Since the early and mid-1980s, the proportion of students taking advanced mathematics and science courses in high school has greatly increased. These gains often include students from underrepresented groups. Nonetheless, the achievement of U.S. students in mathematics has shown only slight gains over time, and there remains a large proportion of students unable to demonstrate anything more than basic levels of knowledge, particularly at grade 12.
- U.S. mathematics and science textbooks contain many more topics and much repetition of material compared with those of other countries. In addition, there is evidence that in the United States, eighth grade mathematics is pitched at a lower level than in higher achieving countries. U.S. students are still working on "high-end" arithmetic while their peers in other countries are studying algebra and geometry.
- The vast majority of U.S. elementary school teachers earn college degrees in education rather than in specific disciplinary areas. High school teachers are much more likely than middle or grade school teachers to possess science and mathematics degrees. Teachers are also frequently assigned to teach classes outside their fields, especially in middle school. The problem is particularly acute in mathematics.

Students often need remedial math and science preparation when entering higher education, but they are succeeding in getting S&E degrees at all levels.

- As students enter college, problems in math and science preparation are obvious. The percentage of freshmen reporting a need for remedial work in math and science has remained high, particularly for women and minorities. In 1995, of those freshmen planning to major in science or engineering, over 16 percent of the males and over 26 percent of the females thought they would need remedial work in mathematics. These data are based on students' self-evaluations and may also reflect various levels of confidence.
- Nevertheless, the number of earned bachelor's degrees in S&E from U.S. institutions has increased from over 307,000 in 1981 to 378,000 in

1995. By the mid-1990s, more than 5 percent of the college-age population had completed a bachelor's degree in a field of natural science or engineering (NS&E).

- Enrollment in undergraduate programs by underrepresented minorities has increased for over a decade, and this trend accelerated in the 1990s. In 1995, however, only about 2 percent of black and Hispanic college-age youth earned a bachelor's degree in an NS&E field.
- Total enrollment in U.S. graduate S&E programs grew for almost two decades and has now begun to shrink. Graduate enrollments of foreign students and white males have dropped. A long trend of steady increases in the enrollment of full-time graduate students whose primary source of support was the Federal Government also ended in 1995.
- At the master's degree level, science and engineering overall showed a great increase in the numbers of earned degrees throughout the 1980s, with the trend becoming even stronger in the 1990s. The recent growth is mainly in the social sciences and engineering, with relatively stable numbers in the natural sciences, mathematics, and computer sciences. The proportion of master's degrees in S&E fields earned by women and minorities has increased over the last two decades.
- The number of doctoral degrees in engineering, mathematics, and computer sciences doubled from 1985 to 1995. Much of this growth involved foreign doctoral recipients; the number of doctoral degrees they earned in S&E fields doubled from over 5,000 in 1986 to over 10,000 in 1995.

Increased attention is going to the extent to which research and education are integrated and the role of the Federal Government in supporting both R&D and graduate students.

- The Federal Government is the main source of support for graduate students via several support mechanisms. A majority of traineeships in both private and public institutions (53 percent and 73 percent, respectively) are financed primarily by the Federal Government, as are 60 percent of the research assistantships in private institutions and 47 percent in public institutions.
- The prevalence of research assistantships as the primary mechanism of support for full-time graduate students in science and engineering has increased considerably. Research assistantships were the primary support mechanism for 66 percent of the students whose primary source of support was from the Federal Government in 1995, compared with 55 percent in 1980.

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"Ignorance is the night of the mind,
a night without a moon or star."

CONFUCIUS

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"Perhaps the most profound discovery
of the 20th century is the
sudden confrontation with
the depths of our ignorance."

LEWIS THOMAS

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- The National Institutes of Health and National Science Foundation are the two federal agencies that have been the primary sources of support for full-time S&E graduate students relying on research assistantships as their primary support mechanism. Nonetheless, other agencies have varying and important impacts on graduate education in specific fields.
- Research assistantships are more frequently identified as a primary mechanism of support in the physical sciences, the environmental sciences, and engineering than in other disciplines. They account for less than 20 percent in all the social sciences, mathematics, and psychology.

Graduate education is being reexamined to determine its appropriateness for labor force needs in the future.

- Although there were many changes in labor market conditions for specific science and engineering fields, overall labor market conditions were similar in 1993 and 1995. Overall unemployment rates for science and engineering Ph.D.-holders were 1.6 percent and 1.5 percent, respectively.
- For recent Ph.D. graduates, the unemployment rate went from 1.7 to 1.9 percent. Only 2.4 percent of recent science and engineering Ph.D. recipients reported working in a non-S&E job unrelated to their fields.
- Measured by the percent reporting that they were involuntarily working outside their fields (IOF rate), the disciplines where recent Ph.D. graduates were having the most difficulties in 1995 were political science (11.2 percent), mathematics (9.3 percent), sociology/anthropology (9.1 percent), geosciences (6.8 percent), and physics (6.7 percent). Recent Ph.D. graduates in the biological sciences do very well by this measure, with only a 2.8 percent IOF rate, but other measures suggest a drop in the availability of tenure-track positions for recent biological science graduates.
- Most science and engineering Ph.D.s are currently employed outside of academia. Looking at entire career histories, only a little over half of scientists and engineers—even at the doctorate level—were employed in academia at some point in their careers.
- An estimated 26,900 Ph.D.s who earned their doctorates in the preceding three years entered academic employment in 1995. But the meaning of "academic employment" has changed for these young doctorate-holders. Fewer than 45 percent had regular faculty appointments, compared with over 75 percent in the early 1970s, while the proportion in postdoctorate positions rose from 13 to 40 percent.

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"There is no higher or
lower knowledge, but only one,
flowing out of experimentation."

LEONARDO DA VINCI

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"The value of achievement
lies in the achieving."

ALBERT EINSTEIN

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- Of scientists and engineers in postdoctorate positions in 1993, only 12.1 percent were in faculty positions in a tenure track in 1995; 41.6 percent were still in postdoctorate appointments. Despite this, the length of time being spent in postdoctorate positions appears only slightly greater than that reported retrospectively by those currently in mid-career.
- While most individuals in postdoctorate positions in 1995 reported additional training and other customary reasons for accepting their appointments, 17.1 percent said they were in a postdoctorate because other employment was not available. This rises to 29.3 percent in geosciences and 26.8 percent in physics.

S&E human capital development in the United States continues to show significant unevenness across socioeconomic groups.

- The number of women with doctorates in science and engineering who held academic positions increased to 52,400 in 1995. This represented a new high of 24 percent of total academic employment of these highly trained personnel. Women remained highly concentrated in the life and social sciences and psychology.
- Minority S&E Ph.D. employment in academia continued to grow, reaching 35,300 in 1995, but stayed at low levels for some groups. The 12,800 members of underrepresented groups—black, Hispanic, Native American, and Alaskan Native—accounted for 6 percent of academic doctoral scientists and engineers, up from 2 percent in 1973. Asian employment in 1995 stood at 22,500, 10 percent of the total, up from 4 percent in 1973.
- Women and members of minority groups have tended to enter academic employment at or above their share of recently awarded science and engineering doctorates. Among recent Ph.D.s in academic employment (those with doctorates awarded in the preceding three years) women and underrepresented minorities were employed in rough proportion to their share of newly awarded doctorates to U.S. citizens and permanent visa-holders. Asians were represented well in excess of their share of new Ph.D.s in science and engineering (although many of these are foreign-born).
- In the overall S&E workforce, minorities, except for Asians, are still a very small proportion of employed scientists and engineers in the United States. Asians, with 4 percent of the U.S. population, represented 10 percent of all S&E workers in 1995. Blacks and Hispanics were 3.4 percent and 2.8 percent of the S&E workforce in 1995, well below their shares of the U.S. population (12 percent and 9 percent respectively). Asians, 84 percent of whom are foreign-born, are the best represented minority group

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"In the highly competitive, knowledge-rich, information-intensive, global economy, every individual, no matter what gender, color of skin, or disability, must be provided the opportunity and indeed encouraged to pursue their interests and to develop their talents in science and technology whether it be as a career choice or to be able to exercise full citizenship in the technology and information age we have entered.
Our nation can no longer afford to underinvest in their potential or to have science and technology-illiterate citizens in its democracy."

JOHN GIBBONS
DIRECTOR
OFFICE OF SCIENCE
AND TECHNOLOGY POLICY

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in mathematics and computer sciences, physical sciences, life sciences, and engineering, each at around 10 percent. The underrepresented minorities—blacks, Hispanics, and Native Americans—are most likely to enter social sciences and least likely to enter physical sciences.

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"I spend money on war because it is necessary, but to spend it on science, that is pleasant to me."

George III

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The nation's S&E enterprise is undergoing changes in structure and priorities as we prepare to enter the next century. Major changes are taking place in sector roles in the funding of research and development. The proportion of the Nation's R&D funds provided by the Federal Government has decreased, but the role of the Federal Government is still essential in the areas of basic research and education. Priorities are changing, with defense R&D decreasing in importance and life sciences and health receiving increased funding and attention. The industrial sector provides a majority and increasing share of national funding for research and development. This has implications for the character of activities supported because industrial R&D is primarily concentrated in development and applied research, rather than basic research. In many countries, direct funding is supplemented by R&D tax credits and other indirect mechanisms. Science and technology are increasingly linked, and the role of partnerships and alliances has increased between sectors, within sectors, and internationally. The service sector has a more important profile than in the past. Information technologies are an important driver for the economy and are making an economic and social impact that are just beginning to be understood.

R&D funding patterns have changed substantially.

- R&D expenditures reached an estimated record-setting high of $206 billion in 1997. The rate of R&D investment in the mid-1990s was the highest it has been since the early 1980s, a welcome contrast to the situation in the early part of the decade, when increases in R&D spending failed to keep pace with inflation.
- Most of the R&D increases have been in the industrial sector. Industrial firms now provide two out of every three of the nation's R&D dollars (an estimated $133.3 billion in 1997) and perform three-fourths of the national R&D effort (an estimated $151.4 billion). The major part of industrial R&D is development and applied research rather than basic research.
- Total federal R&D obligations were an estimated $68.1 billion in FY 1997, 12 percent below the 1989 level (in inflation-adjusted dollars). The Federal Government has been steadily losing ground to industry as a source of R&D funds. In 1997, federal agencies provided 30 percent of

all R&D funds in the United States, down from 46 percent at the peak during the defense buildup a decade ago. This decline seems to have tapered off in the mid-1990s.

- Much of this decrease is a result of defense downsizing as priorities change, as well as attempts to control the budget deficit. The Department of Defense (DOD) share of federal R&D spending has been declining since the mid-1980s from its high of two-thirds of federal funds. In 1997, for the first time since the early 1980s, DOD is expected to account for less than half (48 percent) of the federal R&D total.
- The decrease in defense funds is reflected in federal funding of industrial R&D. Between 1987 and 1997, the federal share of total industry R&D performance declined dramatically—from 32 percent down to an unprecedented 14 percent.

Growth in federal support of academic R&D has slowed.

- In 1997, an estimated $23.8 billion was spent for R&D at U.S. academic institutions, representing 12 percent of the total national performance. Academia, however, has a much larger role in basic research, performing more than 50 percent of the nation's effort. Academic R&D activities are concentrated (67 percent) in basic research, with 25 percent in applied research, and only 8 percent in development.
- The majority of academic R&D expenditures in 1995 went to the life sciences, which accounted for 55 percent of total academic R&D expenditures. The next largest amount of academic R&D expenditures was for engineering—16 percent in 1995.
- The Federal Government continues to provide the majority (60 percent) of funds for academic R&D. Academia has experienced a slowdown in the annual rate of growth in federal support. The share of federal funding has declined in each of the broad S&E fields since 1975. The largest decline in the share of federal funding occurred in the social sciences, and the smallest declines were in computer sciences and environmental sciences.
- Federal agencies emphasize different S&E fields in the funding portfolios of academic research, and changes in federal R&D funding by agencies can have varying impacts on R&D funding and graduate education support in various fields. For example, changes in federal funding for defense R&D have affected academic engineering and computer science funding.

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> *"Since the war years, both Congress and the different administrations have shared the conviction that support of research in the Nation's universities and industries represented an investment in the national future."*
>
> D. ALLAN BROMLEY
> FORMER DIRECTOR
> OFFICE OF SCIENCE AND
> TECHNOLOGY POLICY

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"Further increases in the rate of international and intersectoral cooperation in science and engineering are not just desirable in the current environment, they are absolutely vital."

JOSEPH BORDOGNA
ACTING DEPUTY DIRECTOR
NATIONAL SCIENCE FOUNDATION

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Links are increasing between industry and academia.

- Industrial support to academic R&D has grown more rapidly than support from all other sources during the past two decades, but it still is only a fraction (7 percent) of the total.
- Industrial interaction with academia can be seen in more than just financial patterns. Coauthorship by industrial researchers has grown since the 1980s, and in particular with academia. Coauthorship between industrial researchers with researchers outside their sector rose from 27 percent in 1981 to 50 percent in 1995; about two-thirds of these collaborations involved academic researchers.
- Industrial firms are using academic research in their patent applications. The number of science article citations on U.S. patents increased from 8,600 in 1987 to 47,000 in 1996. The rise in citations held for all fields and for papers from all sectors, with the fastest growth in citations to biomedical research and clinical medicine.
- Academic patenting, especially in the biomedical fields, has increased rapidly. The number of academic patents, while small, increased more than sevenfold in just over two decades, from 250 annually in the early 1970s to more than 1,800 in 1995.

The largest increases in industrial R&D are occurring in the S&E-based industries.

- Companies classified in the electrical equipment industry experienced the largest absolute increases and the highest percentage increases in nonfederal R&D expenditures between 1991 and 1995. All of the increase occurred in the electronic components segment, which had a threefold increase in spending during this period.
- Pharmaceutical companies' R&D spending nearly tripled between 1985 and 1995. The most prominent trend in the drugs and medicines industry has been the increase in importance of biotechnology research; more than one-third of drug companies' R&D projects are primarily biotechnology related. In addition, the rapid growth of R&D dollars reflects the high cost of research directed toward developing cures and treatments for various diseases.

New funding mechanisms are gaining in prominence.

- Many countries have supplemented direct funding of R&D with fiscal incentives to increase the overall level of R&D spending and to stimulate industrial innovation. Almost all industrialized countries (including the United States) allow industry R&D expenditures to be 100 percent deducted from taxable income in the year they are incurred, and half of the countries (including the United States) provide some type of R&D tax credit.

- The pool of venture capital grew dramatically during the 1980s and emerged as an important source of financing for small innovative firms. Very little venture capital is actually disbursed to the "struggling entrepreneur" as "seed" money. In 1995, seed money accounted for only 6 percent of all venture capital disbursements; money for company expansion constituted 42 percent.

Cooperative R&D is now an important tool in the development and leveraging of S&T resources.

- There has been a major upswing in the number of inter- and intra-sectoral and international S&T partnerships since the early 1980s. The annual number of new research joint ventures between firms has been growing, with the largest increases occurring in 1995 and 1996.
- Technology transfer activities became an important mission component of federal laboratories in the late 1980s, and more than 3,500 new cooperative research and development agreements (CRADAs) were entered into between 1992 and 1995.

The service sector has increased in prominence, and information technologies are believed to have contributed to the country's shift to a service economy.

- The nonmanufacturing sector now accounts for approximately one-quarter of all R&D investment in the United States, considerably above the proportion it held in earlier decades. This higher profile is largely attributable to the growth of the information technologies (IT) and communication industries.
- An examination of employment patterns of scientists, engineers, and technicians in a portion of the nonmanufacturing sector (wholesale and retail trade, transportation, communications, and utilities) showed a downturn in employment in 1994 from the peak in 1991. The communications industry was one of the few experiencing an increase in employment of scientists and technicians between 1991 and 1994.
- Employment in IT-producing industries is projected by the U.S. Bureau of Labor Statistics to nearly double from 1986 to 2006. This expansion is based almost entirely on expected growth in computer and data processing services. However, employment in IT hardware industries has been declining. Nevertheless, as the demand for IT jobs spreads to other industries, IT occupations are expected to double over the shorter period of

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"Once experienced, the expansion
of personal intellectual power
made available by the computer
is not easily given up."

SHEILA WIDNALL

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"The more one observes,
the more clearly does he see
that it is in the soil of pure science
that are found the origins of all
our modern industry and commerce.
In fact, our civilization is wholly
built upon our scientific discoveries."

HERBERT HOOVER

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1996-2006. Since exact projections are always difficult, this should be taken as a general direction, not an exact level of employment.

- In the United States, software companies attracted more venture capital than any other technology area. In 1995, venture capital firms disbursed a total of $3.9 billion, of which 20 percent went to firms developing computer software or providing software services. Medical and health-related companies were second with 14 percent. By comparison, computer-related companies received just 7 percent of the venture capital distributed in Europe in 1995 and 5 percent in 1996, and European biotech firms received even less. European venture capital is primarily in industries such as machinery and equipment, fashion and leisure products.
- Between 1990 and 1995, the U.S. trade surplus in software technology doubled, and trade in computer-integrated manufacturing technologies generated a sizable surplus. However, since 1992, the United States has had trade deficits in three areas: opto-electronics, electronics, and computers and telecommunications. Large trade deficits with several Asian economies in these three advanced technology areas now exceed the trade surpluses generated from trade with other countries.
- Both South Korea and Taiwan continue to patent heavily in communication technologies and processes used to manufacture semiconductor devices, dynamic and static information storage, and display systems, among other technologies. Both are already major suppliers of computers and peripherals to the United States. These patent data show that they continue to develop new technologies and improvements that will likely support increased presence in the U.S. and global markets.

Science and technology affect our daily lives in many ways. The results of science and engineering findings surround us at work and at home, but the social and economic effects are often difficult to quantify and analyze. Scientific and technological literacy are important. Science and technology skills are increasingly required in many jobs. There is an increased emphasis on accountability and the importance of public understanding and awareness of science and technology. The public should be able to understand the scientific process and be knowledgeable about science and technology discoveries in order to participate more adequately in policy discussions. The information revolution is upon us and is exceedingly difficult to track, let alone understand its myriad implications and effects—both positive and negative. As we go into the next century, it is hard to visualize how our lives will be changed.

Use of information technology is increasing in the workplace, schools, and homes.

- The real net computing capital stock in the private sector was $155.8 billion in 1995. In many industries, the number of employees who use a computer at work is more than 50 percent; in the banking industry, it is 85 percent.
- Several comprehensive studies using a variety of data and methods indicate that there is an overall skill upgrading taking place in the labor force, a trend attributed to the greater use of IT in many occupations. Along with this increased use, the incidence of IT-related injury and employee surveillance in the workplace are on the rise, but the effects on individuals are uncertain.
- Most Americans—57 percent—use a computer at home or at work. This percentage has grown steadily during the last decade, and in 1997 fully 88 percent of college graduates in the United States indicated that they used a computer at work or at home, compared with 60 percent of high school graduates and 21 percent of individuals who did not complete high school.
- Nearly 32 million Americans have access to a home computer that includes a modem, and 18 percent of adults reported in 1997 that they had used an on-line computer service during the preceding year. This is a significant increase in home access to on-line resources since 1995.
- Nearly two-thirds of Americans with graduate education or a professional degree have a home computer with a modem, compared to 31 percent of those with a high school degree. About 41 percent of Americans with a graduate degree said that they use an on-line computer service compared to only 17 percent of those with a high school degree.

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"I cannot do it without counters."

William Shakespeare

The Winter's Tale, IV, iii

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"If we fail to ensure that our children have the technological resources they need to compete in an ever-changing information economy, our nation will be poorer for it."

VICE PRESIDENT ALBERT GORE, JR.

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- Approximately 16 percent of Americans reported having access to the World Wide Web from their home computers in 1997, and 12 percent of adults sampled—representing about 22 million people—indicated that they had previously tried to find some specific item of information on the Web. Around 6.5 million Americans said they had attempted to find health-related information, and about 8.8 million tried to find some scientific information (which would have included information about the environment, space, or computers).
- The use of, and access to, information technology in the classroom is seen as an important (but not sufficient) tool to enhance education, ensure equitable access, and develop computer skills for the overall population. By 1992, 80 percent of all K-12 schools had 15 or more microcomputers for instruction. In 1996, 85 percent of all schools had access to multimedia computers, 65 percent had Internet access, and 19 percent had a satellite dish. Internet linkages are not necessarily widely accessible within schools—in 1996, only 14 percent of instructional rooms had an Internet hookup.
- In fifth grade, more than half (58 percent) of the instructional use of computers is for teaching academic subject matter. By 11th grade, less than half (43 percent) of computer-based instruction is for content; 51 percent is for computer skills training. Meta-analysis of educational studies conducted between the late 1960s and the late 1980s consistently reveals positive effects of computer-based instruction at the K-12 level. Estimates of the order of magnitude vary, but one meta-analysis of 40 studies estimated learning advantages that ranged from the equivalent of one-third to one-half of a school year for K-6 education.
- Questions have been raised over the cost effectiveness of computer-based instruction relative to other forms of instruction. Additionally, significant inequity exists in educational access to computers and the Internet. Schools whose enrollments comprise primarily minority or economically disadvantaged students have one-third to three times less access to these technologies than do schools represented by white or nondisadvantaged students.
- Concerns about information privacy are growing larger and stronger. Two-thirds of the public said that protecting consumer information privacy was very important.

The issues of accountability and communication with the public are drawing increased emphasis.

- About one in five Americans think they are very well-informed about new scientific discoveries and about the use of new inventions and technologies. One in four Americans understands the nature of scientific inquiry well enough to be able to make relatively informed judgments about the scientific basis of results reported in the media.
- In 1997, 75 percent of Americans believed that the benefits of scientific research outweigh any present or potential harms. Despite their positive views of scientific research, Americans are deeply divided over the development and impact of several important technologies, including nuclear power and genetic engineering.
- American adults express a high level of interest in new scientific discoveries and in the use of new inventions and technologies. The public is interested in knowing what is happening in science and technology, and the scientific community needs to communicate its work ever more clearly and effectively.

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"Public opinion is everything. With public sentiment nothing can fail; without it, nothing can succeed."

ABRAHAM LINCOLN

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Chapter 1
Elementary and Secondary Education

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Highlights

INTERNATIONAL COMPARISONS

- **In a 1995 international comparative study on mathematics and science achievement, U.S. students performed comparatively better in science than in mathematics and better at the fourth grade level than at the eighth grade level.** U.S. fourth graders were significantly outperformed in science only by students in South Korea. The United States performed least well, when compared with other nations, in grade eight mathematics.

- **When compared with other countries, U.S. mathematics and science textbooks contain many more topics and much repetition of material.** For example, U.S. general mathematics textbooks for eighth grade students contain an average of 36 different topics, compared with 8 topics in Japanese and 4.5 topics in German texts. In addition, there is evidence that in the United States, eighth grade mathematics is pitched at a lower level than in higher achieving countries. While U.S. students are still working on "high-end arithmetic," their peers in other countries are studying algebra and geometry.

STUDENT PERFORMANCE

- **In national assessments of mathematics and science learning, students are performing as well as—if not better than—the students of 25 years ago.** Nine-year-olds and 13-year-olds scored higher on mathematics and science tests in 1996 than they did in 1973, while performance of 17-year-olds has remained about the same. However, little of the overall improvement in test scores that occurred during this period has come about during the 1990s.

- **There is little evidence of a difference in the mathematics and science proficiency of girls compared with boys** on national assessments of educational progress. The slight difference that has been identified is confined to students in the 12th grade.

- **As of 1996, large differences remain at all grade levels in the achievement scores of black and Hispanic students as compared with whites and Asians/Pacific Islanders.** Native American students generally scored closer to the national average than did blacks or Hispanics.

CURRICULUM AND INSTRUCTION

- **There have been large gains in the proportion of students taking advanced mathematics and science courses in high school since the early and mid-1980s—gains that often include students from underrepresented groups.** In the class of 1994, close to 70 percent of students had completed geometry, 58 percent completed algebra 2, and 9 percent took calculus. Over 90 percent of seniors completed biology, over half completed chemistry, and about one-quarter took physics.

- **Internet access in schools has increased substantially in recent years.** As of fall 1996, 65 percent of public schools reported access to the Internet, a gain of 30 percentage points over 1994 figures. Internet access was more likely in secondary than in elementary schools, in more affluent than less affluent schools, and in schools with low to moderate minority enrollments than in schools with high minority enrollments.

TEACHERS AND TEACHING

- **The vast majority of elementary school teachers earn college degrees in education rather than in specific disciplinary areas.** High school teachers were much more likely to possess science and mathematics degrees: 41 percent had earned a degree in mathematics, compared with just 7 percent of middle school teachers. In science, 63 percent of high school science teachers and 17 percent of middle school science teachers possessed a science degree.

- **Many middle school mathematics and science teachers fall short in meeting recommendations for coursework preparation made by national associations of teachers.** Only 7 percent of middle school mathematics teachers have taken courses in all of the recommended areas and about one-third have completed none of the coursework recommendations. Forty-two percent of middle school science teachers meet the science recommendations in full.

- **All too frequently, teachers are assigned to teach classes outside their fields.** The problem is particularly acute in mathematics. In the 1990/91 school year, 27 percent of students in grades 7 through 12 had a mathematics teacher without at least a minor in mathematics or mathematics education. Out-of-field teaching is more common at middle schools than high schools.

Introduction

Chapter Background

Educators in elementary and secondary schools across the nation are struggling to improve and redesign mathematics and science education so that all students are well-prepared for the beginning of a new millennium. Policymakers are confronted with growing determination that a solid foundation in mathematics, science, and technology is essential not only to the economic but also to the social well-being of the nation. Indeed, a task for today's policymakers, parents, and communities is to ensure that all students are graduated from high school with a quality education that will enable them to contribute productively to society. Toward this end, the United States has set, as a matter of national policy, the goal of its students being first in the world in mathematics and science achievement by 2000.

However, national and international indicators of educational progress suggest that the country is still far from its goal, despite a growing reform movement aimed at achieving excellence and equity in education. Unresolved issues concerning the performance of students and teachers, the quality of instructional materials and teaching, and access to quality education for all students are matters still very much at the center of local, state, and national education agendas. Nevertheless, indications of forward movement abound: students are taking more advanced courses in science and mathematics, teachers are more aware of the need to change their conceptions of teaching and learning, and student achievement in mathematics and science has largely returned to or exceeded the levels set in the 1970s.

The spark for much of the current reforms came from early work in setting standards performed by professional associations of mathematics and science educators. In mathematics, the National Academy of Sciences laid out the broad outlines of mathematics reform in *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* (MSEB 1989). The National Council of Teachers of Mathematics (NCTM) followed with two reports that made more specific recommendations—*Curriculum and Evaluation Standards for School Mathematics* (NCTM 1989) and *Professional Standards for Teaching Mathematics* (NCTM 1991).

During this same period, consensus on new directions for science education was beginning to develop, though actual national standards were some years away. By 1993, the American Association for the Advancement of Science had issued two publications, *Science for All Americans* (AAAS 1989) and *Benchmarks for Science Literacy* (AAAS 1993), and the National Science Teachers Association produced *Scope, Sequence and Coordination of Secondary School Science* (NSTA 1992). These reports, as well as others, led to a national dialog on science standards resulting in the National Academy of Sciences' *National Science Education Standards* (NRC 1996).

The standards for mathematics and science education share many core ideas: high expectations for all students; in-depth study and understanding of core concepts; emphasis on hands-on tasks that promote active engagement with the subject matter; and a strong focus on reasoning, problem solving, and the ability to apply learning within broader contexts.

The standards in both subjects view teachers as the critical agents that enable students to meet these more demanding levels of performance. However, a large proportion of current mathematics and science teachers were trained when conceptions of teaching and learning were very different from today. Consequently, both sets of standards emphasize the importance of professional development for teachers. Previously offered as a sporadic set of brief workshops to train teachers in specific skills, professional development is now portrayed as a career-long process of continuously updating teachers' mathematics and science knowledge and teaching skills (Darling-Hammond 1994a). And although some school systems, schools, and teachers have begun to adopt practices consistent with the standards, mathematics and science educators recognize that full implementation of standards-based reform will take much more time (Jones et al. 1992; Lindquist, Dossey, and Mullis 1995; and NSF 1996).

Like professional development, equity remains an important challenge for educational reformers in mathematics and science education. At its base, equity means that each and every student has access to quality education regardless of background, race, ethnicity, or location. Some of the building blocks for equity are:

- the necessary materials, funding, and resources for standards-based learning to thrive in schools;
- fully qualified teachers who are knowledgeable about the subjects they teach; and
- appropriate instructional strategies, curricula, and tools for assessing student performance (Darling-Hammond 1992).

One of the critical issues currently facing educators is how to achieve equity and excellence amid the complexities born of an increasingly diverse national makeup. Of the 45 million children enrolled in elementary and secondary schools in 1994, approximately 15 million are ethnic or racial minorities and 6 million come from homes where English is not the primary language spoken (NCES 1996b).

There are still more challenges: how to make effective use of the information technologies that are now commonplace in homes and workplaces as tools for reforming education and improving teaching and learning productivity; how to ensure consistency in approach and quality among instructional materials, teaching, assessment of student learning, and policies formed at district or state levels; and, finally, how to continue learning how to improve—and what works and doesn't work in improving—the quality of education.

Clearly, the role education plays in our personal lives and in the nation's well-being has grown over the years. And the challenges in mathematics and science education—and in all school subjects, for that matter—are before us as educators, students, parents, and community members. And although these challenges may differ from those of years past, it is not clear that there are necessarily more of them, nor is it certain that they are any more daunting than they once were. It may be that we are more concerned and know more about mathematics, science, and technology education in this nation than we did 20 or 30 years ago. As shown in this chapter, what *is* certain is that we have a stronger research base and a deeper, more far-reaching set of national and international indicators of performance than ever before. (See "Measuring the Performance of the Education System.")

Chapter Organization

This chapter is organized into three main parts: first, a detailed description of student achievement in mathematics and science is provided; second, curriculum and instruction are examined; and third, teachers and teaching are addressed. These latter two parts are presented because they are the components of the education process thought to have the greatest direct influence on student achievement. The chapter concludes with a summary of trends in these three areas and an interpretation of what this may mean for educational progress.

Under the student achievement section, the performance of U.S. students in both national and international contexts is examined in order to address the following questions:

- Have mathematics and science achievement in the United States improved in the last decade or more?
- Is the achievement of all students, regardless of demographic group, improving?
- How have the coursetaking patterns of U.S. students changed in the last decade and with what effects on achievement?
- How do U.S. students compare with students in other nations in mathematics and science achievement?

The second major section of this chapter, on curriculum and instruction, focuses on the following questions:

- How do the mathematics and science curricula experienced by U.S. students compare with curricula in other countries?
- What are the similarities and differences in the instructional practices and resources used in U.S. and other classrooms?

The third major section of the chapter examines the background of U.S. mathematics and science teachers in national and international contexts. The discussion centers on these questions:

- Are teachers well-prepared for teaching mathematics and science?
- What are teachers' views about teaching mathematics and science?
- What effect is the standards-based reform movement having on the profession of teaching?

Many national and international data sources—all based on national probability samples—have been mined in writing this chapter. The first section of this chapter can be examined from a number of perspectives using a variety of data sources. The discussion here draws on three primary sources: the National Assessment of Educational Progress (NAEP), the Third International Mathematics and Science Study (TIMSS), and the High School Transcript Studies. NAEP is a reliable indicator of achievement for U.S. students. Since the early 1970s, NAEP has conducted trend assessments every two years covering mathematics, science, reading, and more recently, writing. These assessments draw on nationally representative samples of 9- 13-, and 17- year-olds. To date, eight trend assessments have been conducted in mathematics and nine in science.

NAEP also conducts subject matter assessments periodically on a wider range of subjects including history, geography, civics, computer competence, art, and music. Subjects are covered on a rotating basis so that in one assessment, the focus may be on mathematics and science, and in the next, on history and social studies. These assessments draw on nationally representative samples of students in grades 4, 8, and 12 rather than the age groups used in the trend studies. Items in the periodic subject matter assessments are revised from time to time to incorporate new assessment strategies and reflect prevailing professional judgments about what students in a particular grade should be learning. The items used in trend assessments are fixed, so that performance in basic areas of skill and knowledge can be traced over time, even as curriculum emphases change. Results of these two kinds of NAEP assessments are not directly comparable because of these sampling and content differences.

The second source of student performance data used in this chapter, TIMSS, compares the mathematics and science achievement of elementary and secondary students in the United States with the achievement of students in other countries. TIMSS was conducted in 1994-95 by members of the International Association for the Evaluation of Education. It is the largest and most ambitious undertaking of its kind. Forty-five nations took part in TIMSS at the middle school level (seventh and eighth grades), and 27 at the elementary school level (third and fourth grades).[1] Achievement data and background information were collected from students in each country. Teachers and principals supplied information about instructional resources, practices, staffing, course content, and views of mathematics and science teaching. Curriculum guides and textbooks from 46 nations were analyzed to provide information on the content and skills students in different countries are expected to learn in each grade. Mathematics lessons were videotaped in a sample of eighth grade classrooms in the United States, Japan, and Germany to document differences and similarities in the content presented and the instructional approaches used.

TIMSS results have been published in several reports. Results of curriculum studies are presented in three reports: *A Splintered Vision: An Investigation of U.S. Science and Mathematics Education* (Schmidt, McKnight, and Raizen

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[1] At the time this chapter was written, 12th grade TIMSS results had not been released.

Measuring the Performance of the Education System

Few countries have a truly unitary national education system. Many are aggregations of smaller (e.g., regional) subsystems coordinated by an overall national entity. Most of the 49 countries that participated in TIMSS, for example, have fewer than five subsystems. In the case of some nations—such as the United States—these subsystems (i.e., states) are more or less autonomous, with only indirect influence exercised at the national level (Schmidt, Raizen et al. 1997).

Schmidt, Raizen et al. point out that policymaking is affected by the degree of complexity within the national education system. Countries with a unitary system can make policy about curriculum and decisions about system performance measurement with greater ease than countries with more complex, decentralized systems (Schmidt, Raizen et al. 1997).

The U.S. educational "system," then, is more accurately a multiplicity of systems that can be described from numerous perspectives. It is useful to keep various dimensions simultaneously in mind when thinking about how to measure its performance. Decisions about learning practices are made and affected by networks of practitioners, researchers, policymakers, parents, and community and business leaders, as well as by students. Decisions about what to teach are reflected in curriculum frameworks and materials, instructional practices, teachers' professional development, and student performance assessments. Decisions about resource use are shared by several levels of government: federal, state, and local—within which are school districts, schools, grade levels, and classrooms—across a country of 268 million people.

The states are the primary agents of education as delegated by the U.S. Constitution. However, a long tradition of local decisionmaking authority about what and how to teach is distributed among parent and teacher groups and school boards for each autonomous school district. No matter how the system is portrayed, the difficulty in measuring it is based in its complexity—a web spanning the nation woven within the boundaries of individual states and communities in the form of people, places, behaviors, and ideas.

Compared with countries around the world, the U.S. education system is distinguished by its size, organization, and—above all else—the diversity of the students it serves. In the 50 states and 11 territories, there are over 14,000 school districts and 87,000 public schools (NCES 1996b).

While trends in student performance and coursetaking, characteristics of curriculum and instruction, and preparation and qualifications of teachers may describe the condition of various elements of the system, they do not necessarily encapsulate the performance of the elements as they interact, work in tandem, or change across the system. How much and in what direction the system components move together (or co-vary), is an indicator of systemwide change (Chubin 1997).

The demand is increasing for valid and reliable indicators in accounting for the use of public resources and in sharing knowledge with parents, educators, and policymakers.

Many of these "systemic" features are affective or qualitative, such as system leadership, partnerships, alignment of policies and practices, and student and teacher creativity. Such systemic qualities have not yet been adequately operationalized into acceptable indicators of a system's performance.

Consistent with this systems notion, the Consortium for Policy Research in Education has developed a potential model for evaluating systemwide change in the context of a Philadelphia reform project sponsored by a large collection of public and private funders. The evaluators have created a scorecard that allows them to make judgments about the degree of change across various elements of the Philadelphia reform, thus enabling them to portray the movement of the system as a whole (CPRE 1996).

New approaches to measurement and measurement tools will be needed to investigate the synergy (or lack thereof) among system components. What is needed are indicators of how these various elements work together or apart, what factors characterize the system, and what their effects are on student achievement. Indeed, NSF has funded several research studies that support these new measurement directions. One such study, performed by Cohen and Hill (1997), has examined the interrelationship among teacher professional development, the use of curriculum materials, and the assessment of student performance in fourth and eighth grade mathematics classes in the state of California. What they found supports the power of measuring the combined effects of system components.

Cohen and Hill found that teachers who participated in professional development based on curriculum materials relevant to reform goals were much more likely than other teachers to report teaching practices aligned with these goals. Moreover, their results suggest that "when educational improvement is focused on learning and teaching academic content, and when curriculum for improving teaching overlaps with the curriculum and assessment of students, teaching practice and student performance are likely to improve" (Cohen and Hill 1997). In other words, Cohen and Hill have begun to measure the synergy among system elements as they relate to instructional materials—and have found evidence that such synergy results in improved student performance.

In general, the U.S. curriculum is not consistent with those of other countries that performed well on the TIMSS assessment. When compared with other countries, U.S. mathematics and science curricula are less focused and include far more topics than is common internationally. The topics—especially in mathematics—tend to remain in the curriculum for more grade levels than is the practice in other countries (Schmidt, McKnight, and Raizen 1997).

The Cohen and Hill study, TIMSS, and other studies supported by NSF are indicative of the research that is needed to address systemic issues. Indeed, much of the TIMSS data is yet to be analyzed, and the richness of the study holds forth the promise of more lessons to be learned. More research on systemwide change in larger and different settings is needed to advance and refine these findings.

This chapter begins to move in the direction of examining systems, both national and statewide, of mathematics and science education at the elementary and secondary level. The various measures of student performance, however imperfect, provide some evidence of system outcomes. There are still many more indicators to be developed that will aid local decisionmakers, state and federal policymakers, educators, parents, and their community partners. Although we do not yet have all of the desirable information, we have much more than we once did, more in mathematics and science than in other subject areas, and more at the elementary and secondary levels than at the postsecondary level and beyond.

1997) and two volumes—one for mathematics and one for science—that present international comparisons, *Many Visions, Many Aims* (Schmidt, McKnight et al. 1997; and Schmidt, Raizen et al. 1997). International achievement and survey results are available in four volumes, one for each subject by grade (Beaton, Mullis et al. 1996; Beaton, Martin et al. 1996; Martin et al. 1997; and Mullis et al. 1997). Results from the survey of eighth grade U.S. teachers are presented in *Mathematics and Science in the Eighth Grade* (Williams et al. 1997). Syntheses of U.S. findings from component TIMSS studies are published in two volumes of *Pursuing Excellence*, one for fourth grade (NCES 1997c) and one for eighth grade (NCES 1996c).

A third major source of information about student performance is the 1994 High School Transcript Study, which is based on the records of over 25,000 seniors who graduated from high school that year. The transcript study reports information such as the mean number of credits earned in each subject field and the percentage of students earning a given number of credits in particular subjects (NCES 1997e).

The discussion of curriculum and instruction is based largely on data from the TIMSS curriculum analyses, video observational studies, and teacher questionnaires. The technology portion of this section is drawn from a recent survey on the status of advanced telecommunications in public elementary and secondary schools (NCES 1997a).

The third section of this chapter, on teachers and teaching, is based on comparisons of data from the TIMSS teacher questionnaires with results from the National Survey of Science and Mathematics Education (NSSME) conducted during the 1993/94 school year (Weiss, Matti, and Smith 1994). NSSME, which was initiated in 1977 and updated in 1985, is one of the most comprehensive sources of detailed information on the preparation and classroom practices of mathematics and science teachers. The discussion of teacher qualifications is supplemented by data from questionnaires administered as part of the 1993/94 Schools and Staffing Survey. (See NCES 1996a.) Information on teachers' efforts to implement educational standards in their classrooms is drawn from a school reform survey conducted in spring 1996 (NCES 1997d).

Do Policies and Socioeconomic Factors Play a Role in Achievement?

Performance differences among states may reflect any number of factors, including differences in educational policy and in demographic characteristics. The 1996 Policies and Practices Survey, conducted by the Council of Chief State School Officers, provides information on several useful indicators of instructional quality: number of mathematics and science credits required for graduation, status of standards implementation, and requirements for teacher licensing (CCSSO 1996). An examination of these variables revealed no systematic patterns that might account for performance differences among states.

In the area of social and economic factors, there are suggestions from some studies that differences in "opportunity" may be linked to differences in student background and other socioeconomic variables. Several studies have shown that poor and minority students are more likely to attend schools with severely limited resources and less well-prepared teachers, more likely to be sorted into low academic tracks that limit their access to advanced mathematics and science courses, and less likely to attend schools that offer these advanced courses (Oakes, Gamoran, and Page 1992).

Performance in mathematics and science may also be influenced by other demographic characteristics such as family background. A study that examined the relationship between increases in achievement and changes in family characteristics in the 1980s found that gains made by white students could be completely accounted for by improved family circumstances over the years examined, but only one-third of the gains made by black students—and virtually none of the gains made by Hispanic students—were explained by these factors (Grissmer et al. 1994).

Student Achievement

Trends in U.S. mathematics and science achievement are mixed, but somewhat positive on the whole. Students are more often taking advanced courses in both subjects, and their performance is slightly improved from, or no worse than, the performance levels set in the 1970s. Larger shares of students—including those from underrepresented racial and ethnic groups—are meeting basic levels of proficiency in both subjects than in past years, although wide gaps in achievement remain between students from these groups as compared with whites and Asians. (See "Do Policies and Socioeconomic Factors Play a Role in Achievement?")

Several studies have attributed differences in mathematics and science achievement to the types of courses students complete (Jones et al. 1992 and Gamoran 1986). Acting on the premise that more high-level courses will result in higher achievement, many states and school districts raised graduation requirements in mathematics and science (as well as in other core subjects) following publication of *A Nation at Risk* by the National Commission on Excellence in Education (1983). Two years before its release, only nine states required two or more years of science and two or more years of mathematics. Fifteen years later, 42 states had put these stricter graduation requirements into place (CCSSO 1996).

Comparisons of U.S. achievement with that of other countries provide another important perspective on how well students and schools are performing. International comparisons reveal that, although U.S. students are performing relatively well in science compared with the rest of the world, there remains much room for improvement in mathematics. The performance of students in high-scoring nations demonstrates what is possible for students to achieve at the elementary, middle, and high school levels in this or any country. And, in so doing, student performance overseas provides information educators and policymakers can use in setting appropriate policies, expectations, and goals. Unfortunately, there is no reliable way to determine if the U.S. standing has improved or worsened in recent years. Comparisons with earlier assessments cannot be made because of methodological differences between the studies, differences in the content tested, and changes in countries participating in these tests. (For further information on performance assessments in general, see "Assessing Student Performance."

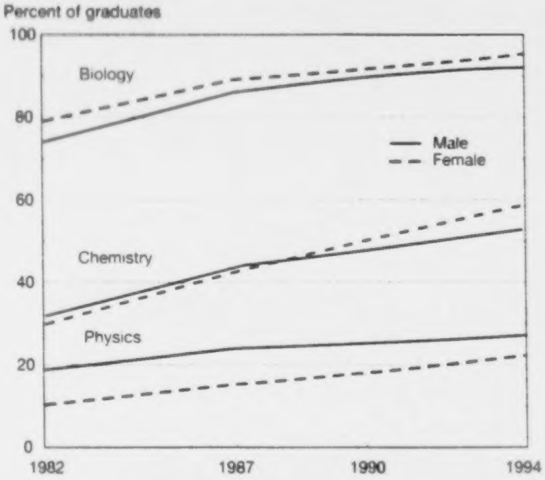
Science Coursework

High school graduates in the 1990s are much more likely to have completed advanced courses in the sciences such as biology, chemistry, and physics. In 1994, 93 percent of graduates had taken biology compared with 77 percent of 1982 graduates. Similarly, more than half now take chemistry compared with less than one-third in 1982, and one in four now complete physics compared with about one in seven in 1982. Although they remain a minuscule fraction of the total, the proportion of students completing advanced placement courses in these science subjects has also increased.

Female graduates are more likely to have taken biology and chemistry in high school than male students, but less likely to have taken physics. This represents a change in the coursetaking patterns of young women as compared with young men. In 1982, female graduates were about as likely as males to have taken chemistry and substantially less likely than males to have taken physics. (See figure 1-1.)

Students from racial and ethnic groups underrepresented in science made substantial gains in the proportions taking advanced science courses. More than 90 percent of blacks, Hispanics, and Native Americans now complete high school having taken biology. In chemistry, the proportion of blacks completing the course doubled (from 22 to 44 percent), rates for Hispanics nearly tripled (from 16 to 46 percent), and completions by Native Americans rose by more than half (from 26 to 41 percent) between 1982 and 1994. Similarly, progress was made in physics coursetaking between 1982 and 1994, although the proportions of students from black and Hispanic groups remain less than 20 percent. The proportion of blacks taking physics almost doubled, and the percentage of Hispanics nearly tripled. No discernible increase in the proportion of Native Americans completing physics was detected over the 12-year period. All in all and despite the progress, there remains a substantial gap in the proportions of blacks, Hispanics, and Native Americans who take chemistry and physics compared with Asian Americans/Pacific Islanders and whites. (See figure 1-2.)

Figure 1-1.
Percentage of high school graduates earning credits in selected science courses, by sex



See appendix table 1-1. *Science & Engineering Indicators – 1998*

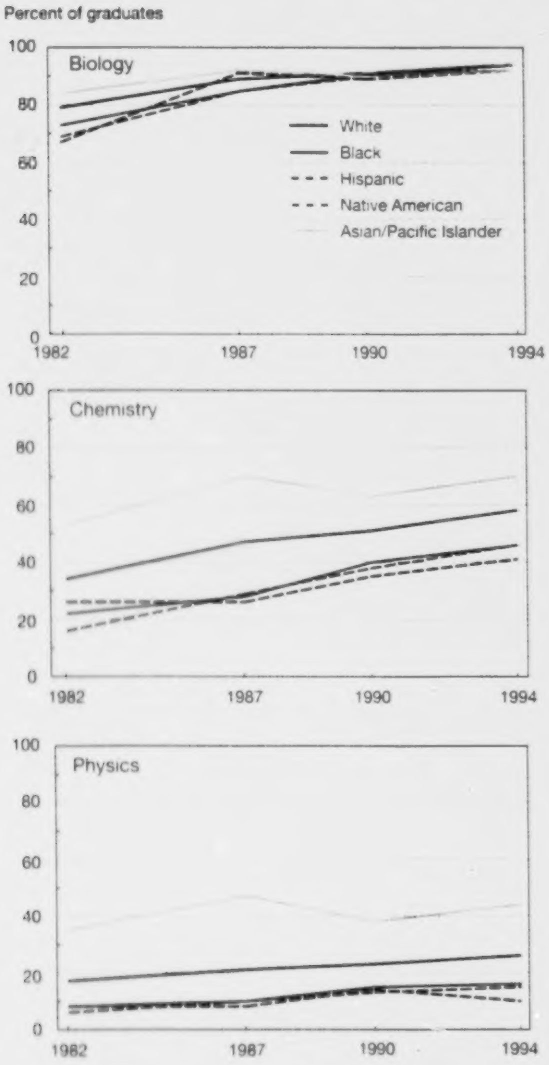
Science Proficiency

In the 1970s, science proficiency scores of elementary and secondary students remained largely flat, but—beginning in the mid-1980s—students began to show improvement. (See figure 1-3.) By the mid-1990s, 9-year-olds and 13-year-olds were scoring slightly higher than their counterparts of 1973, and the scores of 17-year-olds had rebounded to the higher 1973 levels.

Of all school subjects, science in particular has been a sticking point in comparisons of student performance between sexes and among racial and ethnic groups. The underrepresentation of women in the science, mathematics, and technology workplace makes sex-based achievement differences a continuing concern among educators. However, national assessments of educational progress reveal that there are no real differences in science proficiency between 9-year-old girls and boys. Thirteen- and 17-year-old boys edge out girls in science performance, but this difference is small and has narrowed for 17-year-olds since the early 1970s. (See appendix table 1-3.)

Of much more compelling concern at the moment are the racial and ethnic differences that remain in science achievement. The performance of black and Hispanic students at all age groups was far below that of whites in 1996, as has been the case for decades. And although the difference between black and white students has declined for 9-year-olds and 13-year-olds since the 1970s, the disparity for 17-year-olds remains virtually unchanged. There has been no change in the difference between Hispanic and white achievement at any age. Average test scores of Native American students based on a related 1996 science assessment were closer to the

Figure 1-2.
Percentage of high school graduates earning credits in science courses, by race/ethnicity

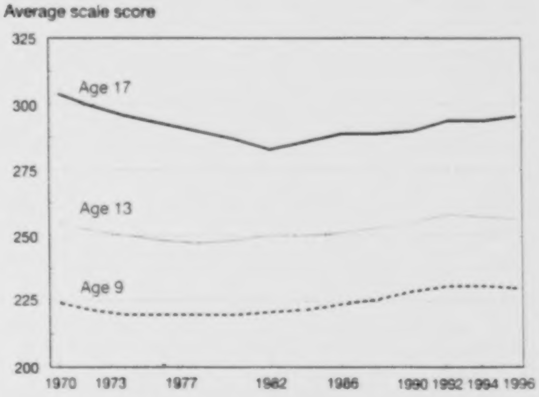


See appendix table 1-2. *Science & Engineering Indicators – 1998*

national average than is the case for black and Hispanic students. Lower achievement is thought to be one reason why minority students make different elective course choices or are screened out of opportunities for more advanced study in science (Oakes 1990).

It is also useful to examine achievement differences across states. Science proficiency was reported on a state-by-state basis for the first time in 1996. (See "The Making of a New Science Assessment.") Figure 1-4 shows how eighth grade students in each participating state compared to the national average. In general, most of the high-scoring states were in the Central, Western, and New England regions of the country, while the majority of the lower performing states were in the Southeast.[2]

Figure 1-3.
National trends in average NAEP scale scores in science at ages 9, 13, and 17



NOTE: NAEP is the National Assessment of Educational Progress.
See appendix table 1-3. *Science & Engineering Indicators – 1998*

Across states, racial and ethnic differences in science proficiency were apparent, and these cross-state differences followed many of the same patterns as overall state-by-state test score differences. That is, students of all races and ethnicities tended to score more highly in states with high overall science performance than in states with consistently lower performance. However, the magnitude of the difference in average scores varied to a surprising degree from one state to another. Average science scores for Hispanic and black populations, for example, fluctuated enormously across different states.

Black students scored below the national average in science in all states. Blacks scored highest in Colorado, but this score was not as high as even the lowest average for whites of any state. The largest achievement gaps between black and white students were in Wisconsin, Connecticut, and New York. With the exception of New York, Hispanic students in states known for their large Latino populations—California, Texas, Florida, and New York—achieved the national overall average score for Hispanic science proficiency.

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[2] States were classified as follows (Reese et al. 1997):

- **Northeast**—Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and (Northern) Virginia;
- **Southeast**—Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, (Southern) Virginia, and West Virginia;
- **Central**—Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin; and
- **West**—Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oklahoma, Oregon, Texas, Utah, Washington, and Wyoming.

The Making of a New Science Assessment

In 1996, in order to better measure the effects of current approaches to science education, the U.S. Department of Education made major changes to subject matter assessment in science through its National Assessment of Educational Progress. The new test represents a departure from earlier ones both in the science that is tested and in the way it is tested. First, factual knowledge is assessed within meaningful scientific contexts. Second, level of performance depends not only on knowledge of facts, but also on the ability of students to integrate this information into a larger body of knowledge, and the capacity of students to use the reasoning processes of science to develop their understanding of the natural world.

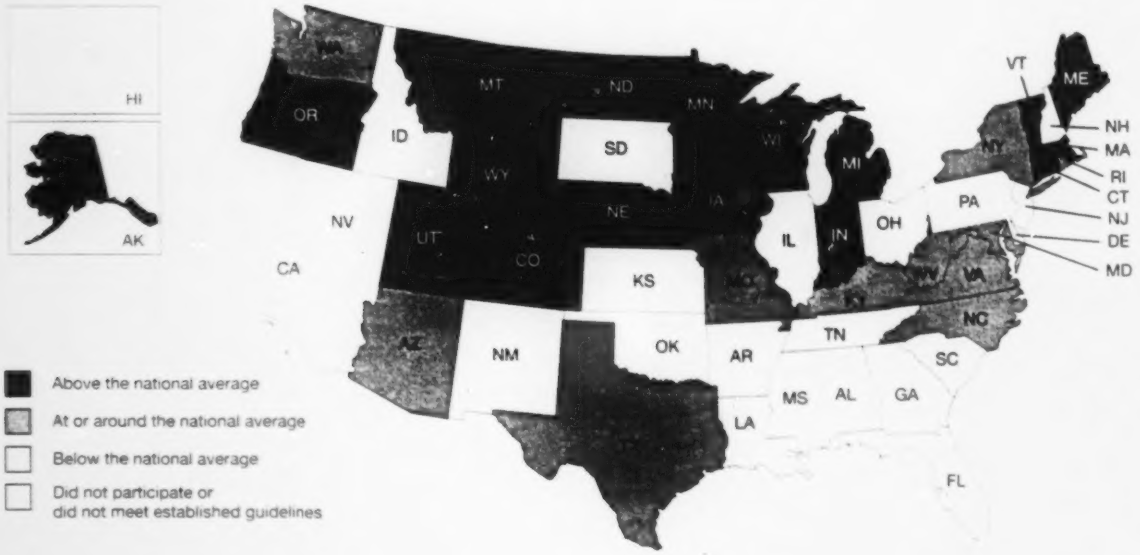
The 1996 assessment used a variety of methods for measuring student performance:

- multiple-choice questions that assess students' knowledge of important facts and concepts and that probe their analytical reasoning skills;
- written response questions that explore students' abilities to explain, integrate, apply, reason about, and communicate scientific information; and
- hands-on tasks that measure students' abilities to make observations, perform investigations, evaluate experimental results, and apply problem-solving skills.

The framework from which the assessment was constructed was developed through a consensus process that brought together science teachers, curriculum experts, other educators, policymakers, members of the business community, and the general public. The framework divides science into three major fields: earth, physical, and life sciences. It also assesses such mental processes important for scientific thinking as conceptual understanding, practical reasoning, and investigation by experimentation.

Although the changes introduced in 1996 mark a meaningful and rich new source of information on student performance, comparisons cannot be made with results of earlier assessments. Consequently, this chapter relies on the NAEP trend assessments in science in making comparisons of student performance over time.

Figure 1-4.
NAEP grade 8 average scale scores in science, by state: 1996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WV
VA
KY
TN
NC
SC
AZ
NM
OK
AR
TX
MS
AL
GA
LA
FL
■ Above the national average
▨ At or around the national average
☐ Below the national average
☐ Did not participate or did not meet established guidelines

NOTE: NAEP is the National Assessment of Educational Progress.

See appendix table 1-4.

Science & Engineering Indicators – 1998

Assessing Student Performance

Assessment—in the educational context—is the *process* of gathering evidence about a student's knowledge of, ability to use, and disposition toward some subject matter with the purpose of making inferences from that evidence for a variety of ends. A test is a measuring *instrument* for evaluating and documenting those outcomes. Simple enough to describe, assessments are not simple to devise nor have they proven easy to integrate effectively within the instructional programs of large education systems. At their conceptual base, assessments are a complex endeavor and the inferences that can be made from them for individual students, teachers, schools, as well as whole educational systems need to be considered with numerous caveats.

There are differences of opinion among educators, researchers, and policymakers about the design and use of standardized and performance-based assessments.

Traditional standardized tests—usually of the short answer variety that are administered, scored, and interpreted in a consistent manner wherever and to whomever given—are the tests that are most often now in place in states and at the national level. But they do not necessarily measure well those aspects of learning such as creativity, deep conceptual understanding, and the ability to apply learning in a number of contexts deemed important or appropriate by many of today's educators. Traditional tests of student performance (answering a question with a single correct short answer) are an efficient method to assess large numbers of students at low cost. However, traditional, norm-referenced, multiple-choice tests are criticized for not adequately measuring complex cognitive and performance abilities. Moreover, they have often been used to limit students' access to further learning opportunities (Darling-Hammond 1991, Glaser 1990, and Oakes 1985).

There are a variety of classroom, school and school district, state, and national tests used for numerous purposes. Their assessment functions include the following:

1. To make decisions about the performance of individual students and comparisons among students.
    - To determine the level or degree of attainment in a specific content area or in a body of content, as a diagnosis of individual strengths and weaknesses in a content area, and as a readiness indicator to determine if an individual has attained the requisite levels of understanding deemed necessary for continued study in a given content area (Bresica and Fortune 1988).
    - To make decisions about student promotion from grade to grade, placement in remedial or advanced level course tracks and for graduation from one educational level to the next (Madaus and Tan 1993).
2. To improve instruction and learning outcomes for students and to inform students, parents, and teachers about student, classroom, school, or district progress over time (Madaus and Tan 1993).
3. To hold educational systems accountable for performance, to make statewide decisions about the allocation of educational resources and interventions, and to assist policymakers and researchers in making evaluative judgments about the performance of existing educational programs and practices or the need for new ones (Madaus and Tan 1993).

The National Assessment of Educational Progress has been conducted in mathematics and science learning since the late 1960s and early 1970s. NAEP uses a formal, systematic procedure to obtain a sample of students' knowledge over time and to make generalizations about how student populations are performing. NAEP has attempted to add performance items to its assessment approach in order to assist in measuring not only students' knowledge of mathematics and science, but also their ability to apply that knowledge and to articulate various aspects of problem solving.

Numerous alternative assessment experiments are being implemented and debated in schools and communities across the nation. Different testing alternatives include performance tasks, open-ended questions, portfolios, observation, and student journal writing and self-assessment.

In recent years there has been a conceptual shift in some research and policy circles as to what constitutes "good" assessments of achievement. Some current trends in measuring and analyzing student performance include:

Notwithstanding the substantial cultural differences and variations in geographic settling patterns across these states and within the U.S. Hispanic population, it was most often in Southeastern states that Hispanic student achievement lagged farthest behind. The largest differences between averages for Hispanics and whites were found in Connecticut, New York, and four Southeastern states. (See appendix table 1-4 for science achievement scores for Asians/Pacific Islanders and Native Americans.)

U.S. Science Proficiency in an International Context

In the recent international comparative study on mathematics and science achievement (TIMSS), U.S. students performed better in science than in mathematics and better at the fourth grade than at the eighth grade level. U.S. fourth graders performed very well on the science assessment—they answered 66 percent of the science items correctly (compared with the international average of 59 percent). The only nation to score significantly higher was South Korea. (See figure

- greater emphasis on assessing higher order thinking skills and processes;
- comparing student performance with established standards;
- making the assessment process public, participatory, and dynamic and including students as active participants in the assessment process;
- ensuring that all students have the opportunity to achieve their potential;
- aligning assessment with curriculum and instruction and other policies and practices;
- making inferences and/or judgments based on multiple sources of evidence; and
- viewing assessment as continual and recursive.

Research findings suggest that achievement tests of any kind are not a good predictor of success. Many forms of bias affect performance on tests: the choice of items, responses deemed appropriate, and the content selected are the product of culturally and contextually determined judgments (García and Pearson in press, Gardner 1983, and Sternberg 1985).

The factors that influence test scores (e.g., opportunities to learn, poverty and social class, test motivation and testing skills, language ability, and educational experiences outside of the classroom) are well-documented. These factors sometimes occur jointly—sometimes at different times—in the test-taking process, making it impossible to track each systematically. As Oakes et al. (1990) point out, although individual effects can be identified for both race and social class, for example, it is the combination of the two—their multiplicative power—that needs to be examined and measured. But new forms of assessment do not themselves remedy these socioeconomic complexities.

Darling-Hammond (1994b) argues that changing test forms and formats without changing the ways in which assessments are used will not change the outcomes of education. The equitable use of performance assessments depends on both the designs of the tests themselves and how well the assessment practices are interwoven with the progress of school reform and the improvement of teaching.

However, an assessment that attempts to perform too many functions will inevitably do none well. Some functions must be passed over in favor of others, and it is at this point that the test development process can become roiled in miscommunication. It is vital to delineate appropriate roles—student diagnosis, curriculum planning, program evaluation, instructional improvement, accountability, and certification—for different assessments (Linn and Herman 1997). And importantly, whatever test is created must be credible in the eyes of the public.

In analyzing test results, their meaning must not be misunderstood. For example, the results of a test given at various grade levels should not be interpreted as if they were an assessment of the progress of the same students over time (i.e., longitudinal). The results of annual achievement data reflect a (cross-sectional) snapshot of progress at that given time. The tests administered as part of TIMSS provide rich information about the performance of U.S. students compared to those of other countries in mathematics and science, and provide connections for understanding performance within the context of curriculum and instruction at specific grade levels. However, TIMSS data are not longitudinal in nature, meaning that the same students are not being tested in the fourth grade and then, four years later, in the eighth.

Much more research is needed on the fairness and validity of new modes of assessment. In addition to these concerns, investigations into the effects of aligning assessments with rigorous standards for student achievement would benefit a multitude of local, state, and federal audiences. Nonetheless, it is not only the *form* of the tests that is important in determining the impact of an assessment program on students, teachers, and schools; it is the *use* to which the results are put (Messick 1989).

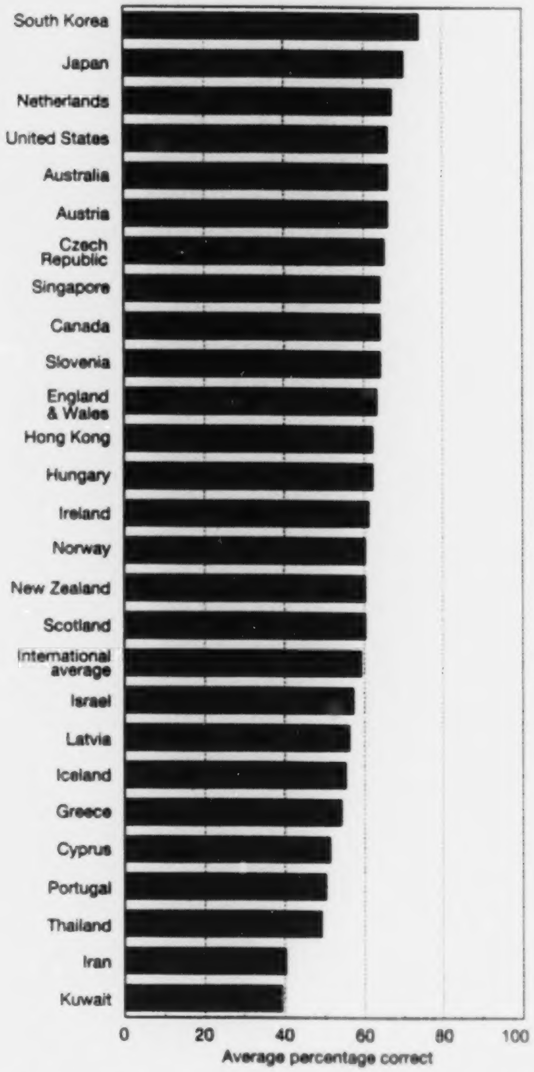
This discussion concentrates heavily on various concerns regarding the measurement of achievement at the elementary and secondary levels, where at least some actions have been taken to assess performance; this is in contrast to the postsecondary level, where gaps remain.

1-5.) In addition, U.S. fourth graders earned scores higher than the international average in all four science content areas: earth science, life science, physical science, and environmental issues/nature of science. (See appendix table 1-5.)

U.S. eighth grade students performed less well relative to other countries in science than fourth graders, scoring just above the international average. Eighth graders in the United States answered 58 percent of the science items correctly, compared with an international average of 56 percent. (See figure 1-6.) Like U.S. fourth graders, scores of U.S. eighth grade students exceeded the international average in all science content areas: earth science, life science, physics, chemistry, and environmental issues/nature of science. (See appendix table 1-6.)

In the United States, boys scored slightly higher than girls in science at the fourth grade, but there was no difference between the sexes at the eighth grade. In other countries that participated in the study, boys outperformed girls in science in 40 percent of the countries at the fourth grade and in almost half of the countries at the eighth grade. (See appendix table 1-7.)

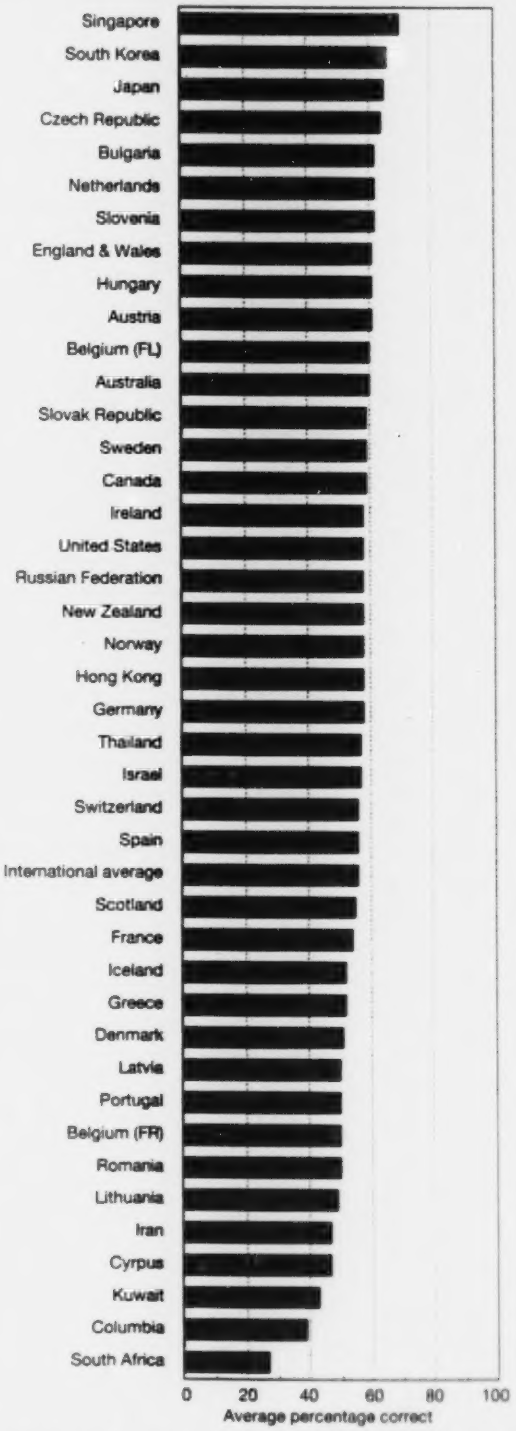
Figure 1-5.
Average percentage correct on grade 4 TIMSS science assessment, by country: 1994-95



NOTE: TIMSS is the Third International Mathematics and Science Study.

See appendix table 1-5. *Science & Engineering Indicators – 1998*

Figure 1-6.
Average percentage correct on grade 8 TIMSS science assessment, by country: 1994-95



NOTE: TIMSS is the Third International Mathematics and Science Study.

See appendix table 1-6. *Science & Engineering Indicators – 1998*

Mathematics Coursework

U.S. students are now much more likely to have taken advanced mathematics courses in high school than they were in years past. In 1994, close to 70 percent of seniors had completed geometry, 58 percent had completed algebra 2, and 9 percent had completed calculus.[3] These figures represent a more than 20-point gain in the percentage of students taking algebra 2 and geometry, and about a 5-point increase in calculus since 1982. High school females are now more likely than males to have taken geometry and algebra 2, and about as likely to have completed calculus. (See figure 1-7.)

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[3] Studies of high school transcripts may underestimate completion rates for algebra 1 (a prerequisite for geometry) because many college-bound students take algebra in eighth grade.

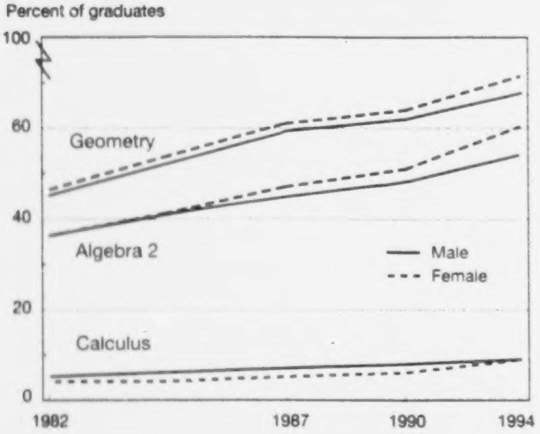
There remain substantial disparities across racial and ethnic groups in advanced mathematics coursetaking. This gap is apparent in geometry and algebra 2 as well as in the most advanced courses in the college preparatory sequence. In calculus, about one-quarter of Asian Americans/Pacific Islanders completed the course compared with about 10 percent of whites, 6 percent of Hispanics, and 4 percent each of blacks and Native Americans.

However, despite the unequal enrollments, progress has been made in the proportion of students in all racial and ethnic groups taking advanced mathematics. Half or more of white, Hispanic, and Asian American/Pacific Islander students in the class of 1994 completed algebra 2 and geometry, the so-called gatekeeper courses for advanced study in mathematics and science. Large gains were made in groups underrepresented in mathematics between 1982 and 1994. The proportion of black students taking geometry increased from 29 to 58 percent between 1982 and 1994. The proportion of Hispanics went from 26 to 69 percent, and the fraction of Native Americans taking geometry rose from 34 to 60 percent over the period. These groups also experienced 20 to 30 percentage point gains in algebra 2. (See figure 1-8.)

Mathematics Proficiency

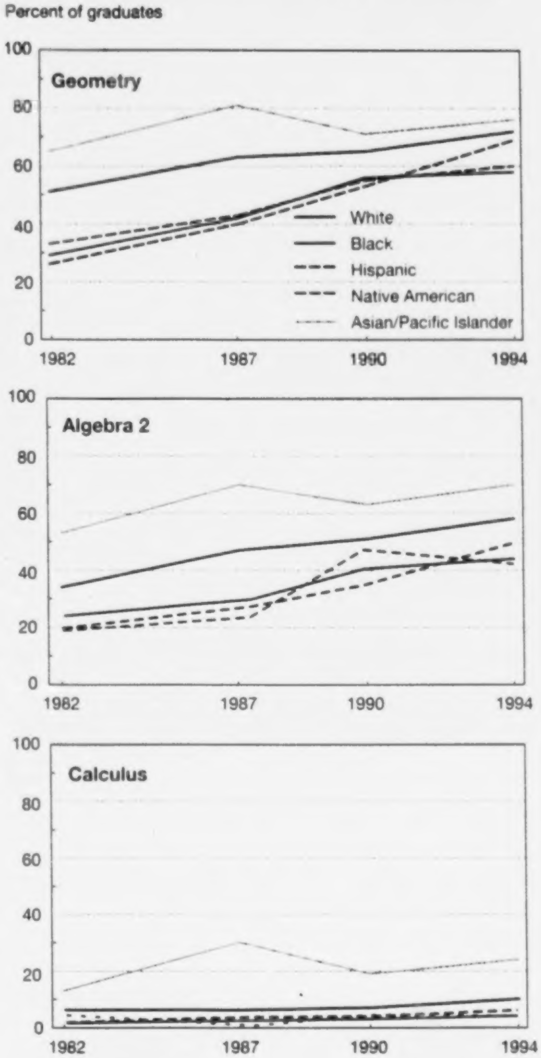
Mathematics performance of U.S. students remained fairly stable during the 1970s and began to improve in the 1980s. The most recent assessments indicate small but significant gains for 9-year-olds and 13-year-olds through 1996. (See figure 1-9.) On the other hand, performance of 17-year-olds remains at the 1973 level after recovering from a slight dip in the 1980s.[4]

Figure 1-7.
Percentage of high school graduates earning credits in selected mathematics courses, by sex



See appendix table 1-8. *Science & Engineering Indicators – 1998*

Figure 1-8.
Percentage of high school graduates earning credits in mathematics courses, by race/ethnicity



See appendix table 1-9. *Science & Engineering Indicators – 1998*

Although the achievement of U.S. students in mathematics has shown slight gains over time, there remains a large proportion of students unable to demonstrate anything more than basic levels of knowledge (often associated with NAEP's level 2 performance). (See "The Making of a New Mathematics Assessment.") This is particularly true at grade 12 where just one in six students performed at or above level 3 (level 4 being the highest). At grades 4 and 8, respectively, approximately one in

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[4] Detailed descriptions of trends can be found in Campbell et al. (1996).

The Making of a New Mathematics Assessment

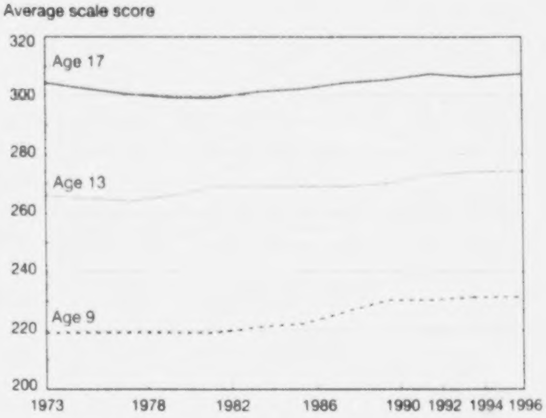
National Assessment for Educational Progress tests in 1990, 1992, and 1996 differed markedly from earlier assessments in that they were designed to reflect the relatively new content and teaching standards published by the National Council of Teachers of Mathematics (NCTM 1989 and 1991). These newer assessments included questions from the five core content areas defined by the mathematics standards:

- number sense, properties, and operations;
- measurement;
- data analysis, statistics, and probability; and
- algebra and functions.

The 1990, 1992, and 1996 mathematics assessments also attempt to measure students' cognitive abilities such as those emphasized in the standards: reasoning, problem solving, and communicating with and about mathematics.

At the same time that standards-based assessments were being developed, efforts were made to associate numerical scores on the test with descriptive labels and definitions that capture the levels of knowledge and skill demonstrated by students' overall responses to test items. Results from the 1990 assessment placed performance on a continuum that ranged from knowledge of "simple arithmetic facts" at the low end to knowledge of "multistep problem solving and algebra" at the high end. Results from the 1992 and 1996 NAEPs were reported at one of four proficiency levels that ranged from "below basic" to "advanced." The value and validity of these proficiency levels have been matters of debate since their introduction (U.S. GAO 1993). To permit comparability with reported results without conveying judgments about the capabilities a particular score represents, this chapter reports performance levels simply designated as levels 1 to 4. These levels correspond numerically to the score ranges used in 1990 and 1992 mathematics assessment reports. (See appendix table 1-10.)

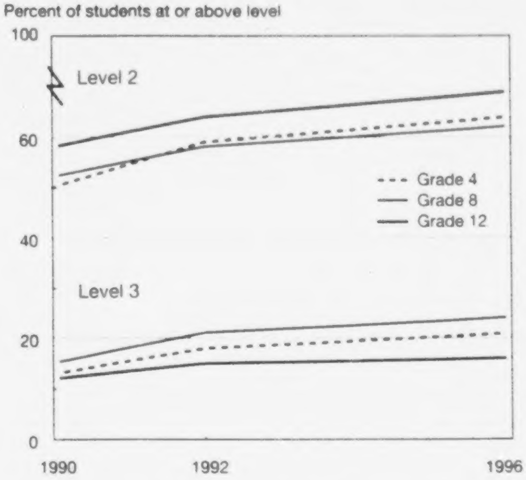
Figure 1-9.
National trends in average NAEP scale scores in mathematics at ages 9, 13, and 17



NOTE: NAEP is the National Assessment of Educational Progress.

See appendix table 1-27. *Science & Engineering Indicators – 1998*

Figure 1-10.
Percentage of students at or above levels 2 and 3 on NAEP mathematics assessments, by grade



NOTE: NAEP is the National Assessment of Educational Progress.

See appendix table 1-10. *Science & Engineering Indicators – 1998*

five and one in four students performed at this level. Despite the disappointing news, this is an improvement from 1990 when substantially fewer students demonstrated level 3 performance.

However, considerable progress has been made in the 1990s in the proportion of students performing at least at level 2. Between 62 and 69 percent—depending on grade level—of students in 1996 were able to perform the more basic levels of mathematics, compared with 52 to 58 percent in 1990. (See figure 1-10.)

In 1996, there were no substantial differences between the proportions of male and female students performing at or above level 2 in mathematics at any grade level. A slightly higher proportion of males than females demonstrated the more advanced performance (level 3) in 4th and 12th grades, but not in 8th grade. (See appendix table 1-10.)

As in science, differences in the mathematics achievement across racial and ethnic groups have followed a consistent pattern over the years: white and Asian American/Pacific Islander students generally achieve at significantly higher levels than do black, Hispanic, and Native American students. Despite some gains between 1990 and 1996, the proportion of black, Hispanic, and Native American students who performed at level 2 or above lagged far behind that of whites and Asian/Pacific Islanders. There were about 40 points between the percentage of white students at level 2 and the percentage of black students, about a 30-point lag for Hispanics, and about 20 points for Native Americans. (See appendix table 1-10.)

Larger proportions of white students in all three grades were performing at or above levels 2 and 3 at the end of the six-year period of the assessment than they were in 1990. The percentage of black fourth graders who performed at level 2 or above increased by 13 points between 1990 and 1996. Hispanic and Native American students showed no statistically significant improvement at any grade or at any level of proficiency during that period.

Also between 1990 and 1996, there has been a striking rise in the number of states where 50 percent or more of eighth grade students scored at or above level 2 mathematics proficiency.[5] In 1996, of the 40 states participating in the state-by-state analysis, only students in Alabama, Louisiana, Mississippi, and South Carolina failed to meet this performance criterion. In comparison, in 1992, only 23 of 35 states, and just half of 1990 participating states, could claim 50 percent or more of their students at or above level 2 performance. (See figure 1-11.) However, there were large differences among racial and ethnic groups across states in meeting the 50 percent criterion. In 1996, half or more of white eighth graders in all states achieved level 2 performance; only in Iowa, Montana, and North Dakota did half or more of Hispanic eighth grade students meet the basic level of proficiency; in no state did half or more of black students perform at this level.[6]

Studies suggest that state economic conditions play some part in mathematics achievement, although a direct and powerful relationship has not been identified. Four states in which less than half of eighth graders functioned at or above level 2 in mathematics (Alabama, Louisiana, Mississippi, and South Carolina) were compared with the six states in which three-quarters or more of students achieved at this level. Comparisons were based on three key variables: poverty rate, educational expenditure, and the percentage of minority students in each state. Comparisons suggest an association between these indicators and mathematics performance. (See text table 1-1.)

- In low-performing states, the poverty index ranged from 19 to 37 percent, and in high-performing states, from 10 to 14 percent.
- In low-performing states, average per student spending on education ranged from $3,660 in Mississippi to $4,761 in South Carolina; in high-performing states, the range was $4,674 in North Dakota to $6,069 in Maine.[7]
- All four of the low-performing states included much larger percentages of minority students (from 40 to 49 percent) than did high-performing states (from 9 to 17 percent).

U.S. Mathematics Proficiency in an International Context

As in science, performance in mathematics of U.S. fourth grade students in the 1995 TIMSS study was comparatively better than eighth grade performance, averaging 63 percent of items correctly answered compared with 59 percent internationally. (See figure 1-12.) But, unlike in science, U.S. mathematics performance at fourth grade was far behind that of Singapore, South Korea, Japan, and Hong Kong—whose fourth grade students averaged 73 to 76 percent correct—and a host of other countries. (See figure 1-13.) U.S. eighth graders answered just over half of the items on the mathematics assessment correctly. This was below the international average of 55 percent correct, and students in the highest performing nations—Singapore, South Korea, Japan, Hong Kong, and Flemish-speaking Belgium—averaged 65 percent correct or higher. In most countries—including the United States—there were no differences between the sexes in mathematics performance at the fourth or eighth grade. (See "Mathematics and Science Achievement of the Highest Performers" and appendix table 1-14.)

Mathematics and Science Achievement of the Highest Performers

Achievement can also be evaluated by comparing the top students in different nations. Often, the comparison is based on the proportion of each nation's students scoring in the top 10 percent of the international distribution. As would be expected on the basis of findings already presented, proportionately more students from Singapore, South Korea, and Japan came out on top in both subjects and at both the fourth and eighth grade levels. For example, at the eighth grade level, 45 percent of the students from Singapore scored in the top 10 percent of the international mathematics distribution and 31 percent scored at the top of the science distribution. A smaller percentage of U.S. students made the top cut. In science, 13 percent of eighth grade students and 16 percent of fourth grade students scored in the top 10 percent of their respective international distributions. In mathematics, only 5 percent of U.S. students in eighth grade and 9 percent of students in fourth grade reached the top 10 percent international benchmark. (See appendix table 1-15.)

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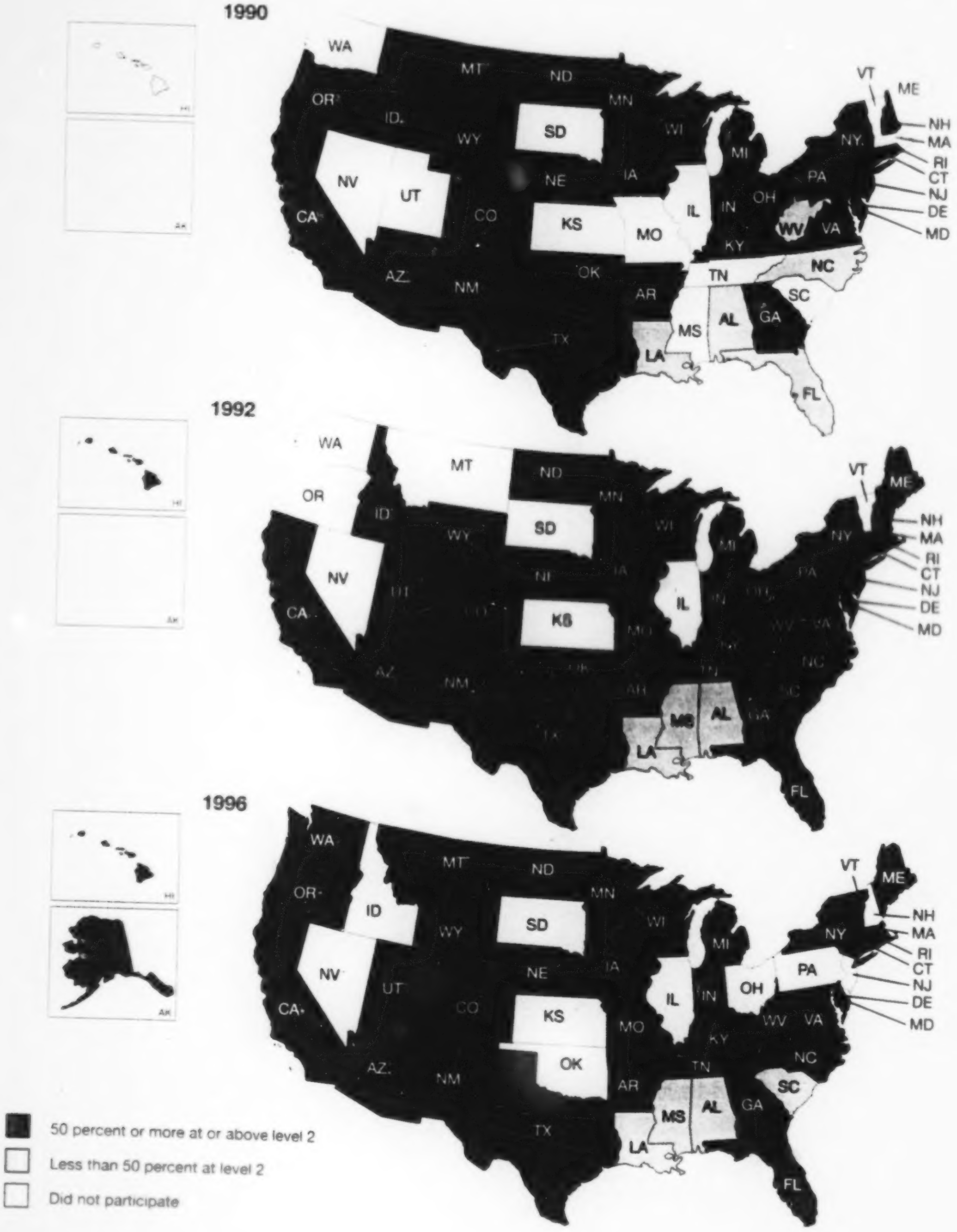
[5] Because only eighth grade students participated in all three of these assessments, only their performance is considered in these comparisons.

[6] Because sample sizes for Native American and Asian Pacific Islander students were too small in most states to provide reliable estimates of proficiency levels, these comparisons are not made here but can be found in appendix table 1-11.

[7] These figures are not adjusted for differences in cost of living among states.

Figure 1-11.
NAEP grade 8 average scale scores in mathematics, by state


1990
WA
OR
CA
NV
ID
UT
AZ
MT
WY
CO
NM
ND
SD
NE
KS
OK
TX
MN
IA
MO
AR
LA
WI
IL
MS
MI
IN
KY
TN
AL
OH
GA
WV
VA
NC
SC
FL
PA
NY
VT
ME
NH
MA
RI
CT
NJ
DE
MD
HI
AK
1992
1996
■ 50 percent or more at or above level 2
☐ Less than 50 percent at level 2
☐ Did not participate

NOTE: NAEP is the National Assessment of Educational Progress.
See appendix table 1-11.

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Text table 1-1.
Selected characteristics of low- and high-performing states on the mathematics National Assessment of Educational Progress: 1996

State	Percentage of students at or above level 2	Percentage of 5- to 17-year-olds in poverty	Per pupil educational expenditures ($)	Percentage of minority students
National total	61	20.1	5,767	31
Low-performing states				
Alabama	45	19.5	4,037	40
Louisiana	38	36.8	4,519	45
Mississippi	36	28.2	3,660	51
South Carolina	48	18.7	4,761	49
High-performing states				
Iowa	78	13.5	5,288	9
Maine	77	9.6	6,069	7
Minnesota	75	13.7	5,720	14
Montana	75	12.3	5,598	17
Nebraska	76	12.5	5,651	15
North Dakota	77	11.6	4,674	9

SOURCES: C. O'Sullivan, C. Reese, and J. Mazzeo, *NAEP 1996 Science Report Card for the Nation and the States* (Washington, DC: National Center for Education Statistics, 1997); C. Reese, K. Miller, J. Mazzeo, and J. Dossey, *NAEP 1996 Mathematics Report Card for the Nation and the States* (Washington, DC: National Center for Education Statistics, 1997); and National Center for Education Statistics, *Digest of Educational Statistics 1996*, NCES 96-133, (Washington, DC: U.S. Government Printing Office, 1996), table 165.

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The performance of students varied over mathematics content areas both within and among countries.[8] In fourth grade mathematics, U.S. students performed at or above the international average in all areas except measurement. (See appendix table 1-12.) U.S. eighth grade students performed best on algebra, fractions, and data representation/analysis, where performance was on a par with international averages. They did less well on proportionality, geometry, and measurement. (See appendix table 1-13.)

Curriculum and Instruction

When student assessments reveal differences in performance across nations or states or within population groups of the magnitude that they have displayed in the assessments analyzed here, there is a compelling policy need to explore the sources of these disparities. A better understanding of why some groups of students perform well in mathematics and science while others do not can help educators and policymakers in deciding which facets of the education system require more or less attention.

Many recent analyses have focused on differences in the educational experiences of students. The Third International Mathematics and Science Study provides more comprehensive information on the educational experiences of students than any international (and many national) studies conducted to date. Within this large-scale study, a curriculum analysis provides country profiles of the mathematics and science that students are expected to learn at each grade.[9] Student and teacher surveys provide information on the subject matter content and activities that make up a lesson; and a video study (for the United States, Germany, and Japan) provides observational information on what actually takes place in a sample of eighth grade mathematics classrooms.

Mathematics Curricula

In most countries, curricula focus on a limited number of topics at each grade. Each topic is introduced in the grade sequence and continues until a point when it is discontinued in favor of a new topic. In contrast, U.S. curricula follow a spiral approach: a topic is introduced in its simplest terms in early grades and continues in more advanced forms into later grades. Topics thus "spiral" throughout the curriculum—in theory, providing greater depth, elaboration, and complexity at each appearance. Three central ideas underlie the U.S. approach. First, content is more easily mastered when broken into "bite-sized" pieces. Second, the pieces are best learned when presented in order of difficulty and complexity. Third, students must master each piece before moving on to the next.

However, this approach when put into actual practice has important consequences for learning and instruction that are not always consistent with the theory. The U.S. curricula include a great deal of repetition over grades, and despite the intent to present new aspects of a topic at each appearance.

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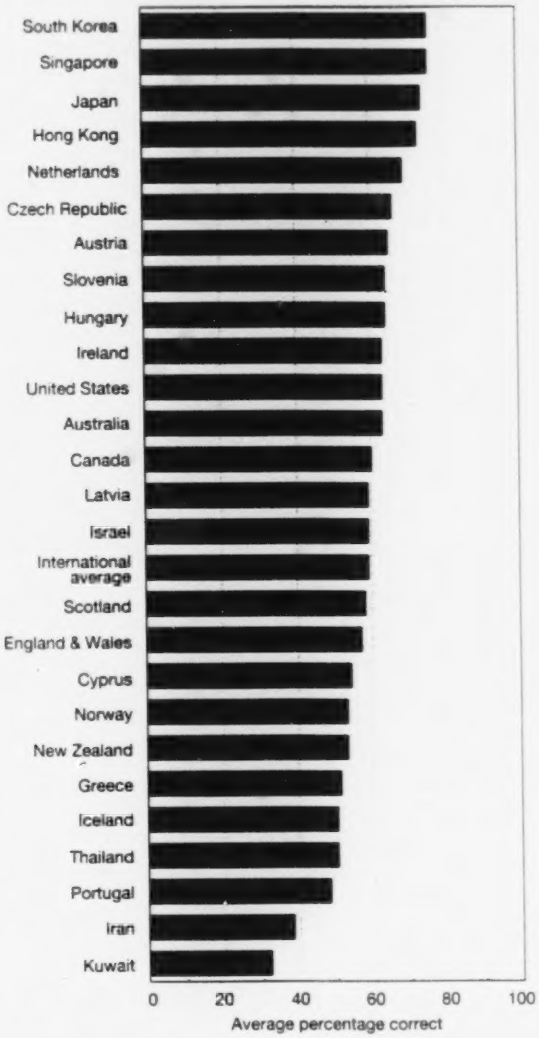
[8] Items and topics in the assessment were grade-specific. For example, the fourth grade test focused on whole numbers with a limited number of questions on fractions. The eighth grade test focused on rational numbers (fractions and decimals)

[9] Details of the curriculum study's methodology and findings are presented in Schmidt, McKnight, and Raizen (1997) and in two companion volumes (Schmidt, McKnight et al. 1997 and Schmidt, Raizen et al. 1997)—one for science and one for mathematics—written by these and other members of the TIMSS research team.

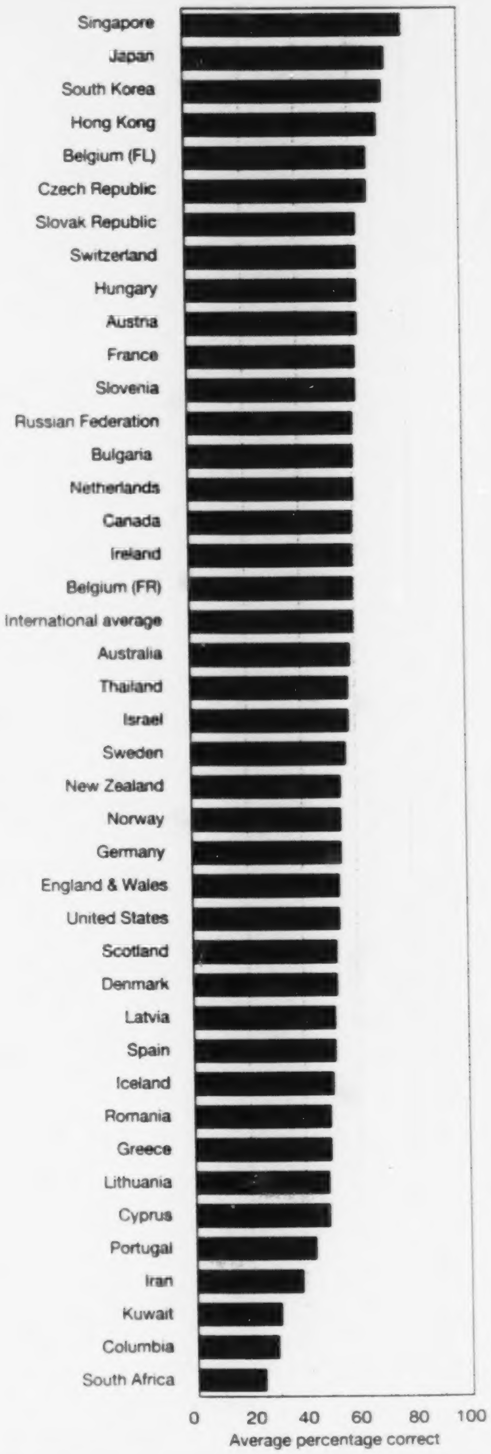
Figure 1-12.
Average percentage correct on grade 4 TIMSS mathematics assessment, by country: 1994-95



NOTE: TIMSS is the Third International Mathematics and Science Study.

See appendix table 1-12. *Science & Engineering Indicators – 1998*

Figure 1-13.
Average percentage correct on grade 8 TIMSS mathematics assessment, by country: 1994-95



NOTE: TIMSS is the Third International Mathematics and Science Study.

See appendix table 1-13. *Science & Engineering Indicators – 1998*

much of the information seems to get rehashed from previous levels. On average, topics remain in the mathematics curriculum as a whole two years longer than is the norm internationally. And the curriculum includes a large number of topics since few are dropped as others are added. On average, the U.S. mathematics curriculum covers more topics than are covered in 75 percent of countries that participated in the 1995 international study.

Analyses of topics covered at various grade levels in mathematics textbooks across the world illustrate this point. At fourth grade, the five most emphasized mathematics topics accounted for 60 percent of page space in U.S. textbooks but over 85 percent internationally. In eighth grade mathematics, the five most emphasized topics in U.S. (nonalgebra) texts accounted for less than 50 percent of total coverage, compared with 75 percent internationally.[10] U.S. eighth grade textbooks for regular, nonalgebraic mathematics cover approximately 36 different topics, compared with an average of 8 topics in Japanese and 4.5 topics in German texts.[11] Findings are similar for the 4th and 12th grades. (See figure 1-14.)

A review of the topics emphasized at each grade level reveals that U.S. mathematics texts are also often out of step with the international norm. For example, at eighth grade—where U.S. students perform relatively poorly in mathematics compared with other nations—the international norm is to focus on algebra and geometry. In the United States, eighth grade texts place greater emphasis on whole numbers, decimals, and fractions—topics that most other countries have already completed. Videotaped lessons confirm this finding. Lessons in German and Japanese classrooms were focused on algebra and geometry, while, in about 40 percent of the cases, U.S. lessons focused on arithmetic (NCES 1996c).[12]

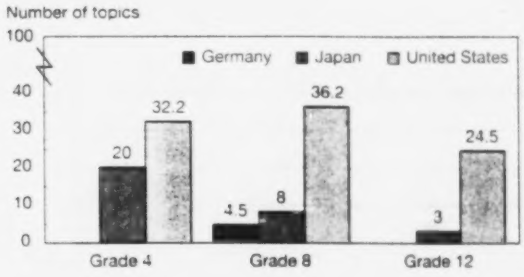
Science Curricula

Overall, the U.S. science curriculum has more in common with the curricula of other countries than is the case for U.S. mathematics. Still, U.S. science curricula reflect some of the patterns observed in mathematics. In the United States, new topics are introduced at regular intervals in the first five grades. Much of the content seems repetitive until about 10th grade, when general science is replaced by courses devoted to specific areas of science such as biology, chemistry, or physics.

However, in the elementary and middle grades, U.S. students take general science courses that cover more topics than are covered in most of the participating countries. General science textbooks in the United States tend toward inclusiveness, covering more distinct topics than are covered in texts in 75 percent of the other countries. The typical U.S. science textbook covers between 53 and 67 topics, depending on grade level. In Japan, the range is 8 to 17 topics. In Germany, where data were available only for eighth grade, the average is nine topics. (See figure 1-15.)

This tendency toward inclusive coverage means that most general science textbooks in the United States touch on topics rather than concentrating on them. As an example, the five most emphasized topics in U.S. fourth grade science texts accounted for 25 percent of the total textbook space, compared with an international average of 70 to 75 percent. In eighth grade, the five most emphasized topics in U.S. general science texts accounted for 50 percent of textbook space, compared with 60 percent internationally.

Figure 1-14.
Average number of topics in mathematics textbooks in Germany, Japan, and the United States, by grade: 1994-95



NOTE: Data are from the Third International Mathematics and Science Study. Eighth grade algebra texts not included.

SOURCE: W.H. Schmidt, C.C. McKnight, and S.A.Raizen, *A Splintered Vision: An Investigation of U.S. Science and Mathematics Education* (Boston: Kluwer Academic Publishers, 1997).

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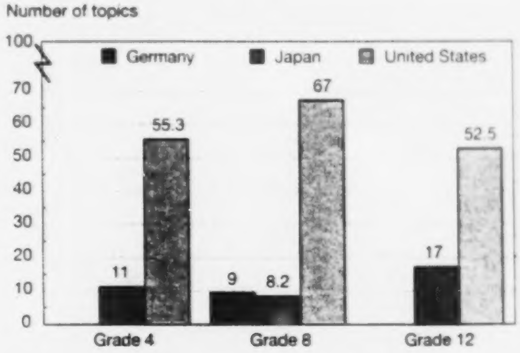
Figure 1-15.
Average number of topics in general science textbooks in Germany, Japan, and the United States, by grade: 1994-95



NOTE: Data are from the Third International Mathematics and Science Study.

SOURCE: W.H. Schmidt, C.C. McKnight, and S.A. Raizen, *A Splintered Vision: An Investigation of U.S. Science and Mathematics Education* (Boston: Kluwer Academic Publishers, 1997).

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[10] The five most emphasized topics in eighth grade algebra texts in the United States accounted for 100 percent of textbook space.

[11] Results of the curriculum analysis for German texts are reported only for eighth grade.

[12] Key findings from the video summary are presented in NCES (1996c). Details of the methodology, coding schemes, and findings have been presented in a recently issued volume prepared by James Stigler and colleagues at UCLA (Stigler et al. 1997).

Instructional Practice and Quality

Textbooks and curriculum guides are not the only critical factors in curriculum and instruction. Equally critical from the perspective of educational reformers are instructional considerations such as the amount of time students spend engaged with subject matter, the kinds of tasks used to facilitate their problem-solving and thinking capacities, and the technological tools available to support active student learning.

Differences in student performance outcomes are determined, at least to some degree, by differences in instructional practice and instructional quality. Science instruction in the United States may be roughly comparable to science instruction in other countries. But, as revealed in the recent international comparison, eighth grade mathematics classes in the United States are pitched at a lower level than in higher achieving countries. While U.S. eighth graders are still working on "high-end arithmetic," their peers in other countries are learning algebra and geometry.

The international comparison also revealed differences in goals, activities, and overall lesson quality in the United States, Germany, and Japan. The goal of mathematics lessons in the United States and Germany was most often to have students learn a particular skill, while the goal in Japanese classrooms was more often to help students develop deep understandings of mathematics (see NCES 1997c). These differences in goals translated into differences in other aspects of instruction. For example, 71 percent of Japanese teachers provide learning activities that require high-level thinking and reasoning. In comparison, only 29 percent of German teachers and 24 percent of U.S. teachers engaged students in this kind of learning (NCES 1997c).

On the basis of a videotaped sample of eighth grade mathematics classrooms in the three countries, judges rated most lessons from U.S. classrooms to be of low quality (87 percent), compared with 40 percent of lessons from German classrooms and just 13 percent of Japanese lessons. These judgments were made independently of detailed summaries that documented the exact sequence of mathematical statements and equations presented and the learning activities used. Any words that provided clues to the identity of the country were disguised.

None of the lessons from U.S. mathematics classrooms were rated high on quality, compared with 30 percent of lessons from Japanese classrooms and 23 percent from German classrooms. Moreover, most of the expert judges viewed lessons in Japanese classrooms as more consistent with U.S. mathematics standards than lessons in U.S. classrooms. However, 75 percent of the U.S. teachers of those same lessons judged their own instruction to be in "some accord" with the standards.

Time on Learning

Aside from the issue of instructional quality, there has been some empirical evidence to support the common-sense notion that the more time students spend engaged in learning, the more they will learn. This is the primary reason why time is considered an important instructional variable. It is considered so crucial, in fact, that many educators believe systemic change cannot be successful in schools unless ways are found to provide students with more learning time (National Education Commission on Time and Learning 1994). Still, questions remain about just how much influence instructional time has on achievement.

Through the recent international comparative study, it has become clear that, at the very least, the relationship is not as simple as has been assumed. In fact, no consistent relationship was observed between class time and achievement in either subject at either fourth or eighth grade.[13] This finding suggests that how teachers and students spend their instructional time is more important than the amount of time available for mathematics and science instruction during the school day. For example, eighth grade students in Belgium, the Czech Republic, and the Slovak Republic—all high-performing nations—reported spending more time than the average on mathematics. But so too did students in Kuwait, who were among the lowest scorers. South Korean and Japanese eighth graders reported spending the international average amount of class time on mathematics but were among the highest achievers.

U.S. students spend at least as much class time on mathematics and science as students in most countries. At eighth grade, over half of U.S. students spend $3\frac{1}{2}$ to 5 classroom hours on mathematics each week compared with an international norm of 2 to $3\frac{1}{2}$ hours (Beaton, Mullis et al. 1996; and Beaton, Martin et al. 1996).[14] Almost half of fourth grade U.S. students spend five or more hours of instructional time each week on mathematics and three hours or more on science. In most other countries, fourth graders spend about three to four hours on mathematics and two hours on science (see Martin et al. 1997 and Mullis et al. 1997).[15]

Although learning time can be extended through homework and study before or after the school day, no consistent relationship has been found between international achievement and the amount of time students reported spending on homework. In some high-achieving countries such as Hungary, Singapore, and Slovenia, students spend considerably more time than the norm on homework. However, students in low-achieving countries such as Iran and Kuwait also reported considerable time on homework. In Denmark, Scotland, and the Netherlands—which are middle- to high-achieving countries—one-quarter to one-half of the students reported spending no time at all on homework on a normal day.[16]

Students in most countries reported spending an hour of nonschool time on mathematics on a normal day and a half-hour to an hour on science. U.S. students averaged 48 minutes to one hour on mathematics homework and between 36 and 48 minutes on science, depending on grade level (Beaton, Mullis et al. 1996; Beaton, Martin et al. 1996; Martin et al. 1996; and Mullis et al. 1996).[17] (See appendix table 1-17.)

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[13] See table 4.9 in each of the following sources: Beaton, Mullis et al. 1996; Beaton, Martin et al. 1996; Martin et al. 1997; and Mullis et al. 1997.

[14] See Beaton, Mullis et al. (1996, table 5.5). Comparable figures are not available for eighth grade science classes in the United States.

[15] For mathematics, see Mullis et al. (1997, table 5.4); for science, see Martin et al. (1997, table 5.5).

[16] See table 4.9 of Beaton, Mullis et al. (1996); and Beaton, Martin et al. (1996).

Homework competes with extracurricular activities for students' attention, and television often turns out to be the prime competitor. In most countries, eighth grade students spend two to three hours a day watching television. (See figure 1-16) The habit of U.S. students are consistent with these patterns: eighth graders reported spending 2.6 hours watching television, compared with 2.3 hours doing their school homework or studying. Not only was this within the international norm, but it was virtually identical to patterns exhibited by Japan and Hong Kong, two of the top-scoring economies. Students in other high-scoring countries such as Singapore and Belgium spent somewhat more time studying than watching television; however, students in the Czech Republic spent more time watching television than studying.

The relationship of achievement to time spent viewing television is more consistent than the relationship between achievement and time spent on homework—but it turns out to be a curvilinear relationship. Students who watched one to two hours of television were the highest achievers in most countries. Students who watched more than two hours of television or less than one hour had lower mathematics and science achievement on average. More significant perhaps was the finding that eighth grade students who watched television for five or more hours each day, and fourth grade students who watched TV for four or more hours, were the lowest achievers in all participating countries. The United States had a fair number of students who spent this much time watching television—17 percent of fourth grade students and 13 percent of eighth grade students (Beaton, Mullis et al. 1996; Beaton, Martin et al. 1996; Martin et al. 1997; and Mullis et al. 1997).

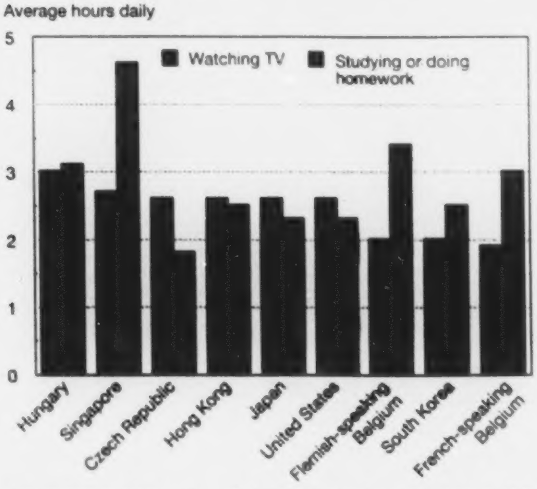
Use of Instructional Technologies

Educational standards in both mathematics and science acknowledge the potential benefits of technology and recommend that students have regular access to computers and other tools such as calculators. Although there are studies of individual schools or districts where the use of computers and access to the Internet have yielded learning gains, there are no national data that affirm that the presence of technology in itself is spurring achievement gains in mathematics and science nationwide. It is probably often the case that information technologies, when available, are not being used effectively in the classroom; nor does it seem from empirical analysis that educators have yet understood how to integrate technology into programs of reform on a wide scale.

By 1994, more than half of U.S. middle and high school students reported access to computers in school for mathematics instruction; of that number, about 62 to 70 percent actually used the computers to solve mathematics problems. This represents a large increase from 1978 when only 56 percent of 13-year-olds and 46 percent of 17-year-olds used computers for problem solving during instruction. (See text table 1-2.)

Teacher responses from recent international comparisons paint a slightly more limited picture of computer use for mathematics

Figure 1-16.
Average hours spent on homework and in watching TV, by eighth graders: 1994-95



See appendix table 1-17. *Science & Engineering Indicators – 1998*

Text table 1-2.
Percentage of students reporting school access to computers for mathematics instruction and learning

Computer access/use	Year	13-year-olds reporting yes	17-year-olds reporting yes
Had access to computer to learn	1978	12	24
	1994	48	52*
Studied through computer instruction	1978	14	12
	1994	50*	34*
Used a computer to solve problems	1978	56	46
	1994	70*	62*

* = statistically significant difference between the two years, at a 5 percent combined significance level per set of comparisons

SOURCE: J. Campbell, C. Reese, C. O'Sullivan, and J. Dossey, *NAEP 1994: Trends in Academic Progress* (Washington, DC: National Center for Education Statistics, 1996).

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instruction. When asked about the use of computers in mathematics instruction, three-quarters of U.S. teachers at the eighth grade level reported that students never or hardly ever solve mathematics problems using a computer. Sixty percent of U.S. fourth grade teachers reported that students never or hardly ever use the computers in solving mathematics problems.[18] However, mathematics teachers reported frequent instructional use of calculators. More than half of eighth grade mathematics teachers in the United States reported that students in their classes use calculators for basic tasks such as checking answers and performing routine computations. More than half also reported having their students use calculators to solve complex problems and more than one-third to explore number concepts (Williams et al. 1997). (See appendix table 1-23.)

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[17] Beaton, Mullis et al. (1996, table 4.6). Also see table 4.9 of Beaton, Mullis et al. (1996); Beaton, Martin et al. (1996); Martin et al. (1997); and Mullis et al. (1997) for frequency if distribution of homework study time.

Across the world, computers are used quite rarely for mathematics and science instruction. Except in Denmark, England and Wales, and Slovenia, less than one-fifth of eighth grade students used computers for problem solving in science. And except in the United States, [illegible]ia, Denmark, England and Wales, and Sweden, less than one-third of fourth grade students used computers at least some of the time according to teachers' reports. (See appendix table 1-[illegible]6.)

Limited availability of computers at school can be offset by access to computers at home, even though home computers are often used for other than academic purposes. During the 1994/95 school year, about half of U.S. students had a computer at home. Students in England and Wales, Iceland, Ireland, the Netherlands, and Scotland were most likely to own computers (about 75 percent); students in Colombia, Iran, Latvia, Romania, and Thailand were least likely (less than 20 percent). (See text table 1-3.)

The vision of tomorrow's classroom held by many educational reformers not only includes access to computers by students and teachers but also widespread access to the Internet. Although most U.S. schools are quite far from this vision, Internet access in schools has increased substantially in the last several years. A recent survey indicated that in fall 1996, 65 percent of public schools reported access to the Internet—a gain of 30 percentage points over 1994 figures. Internet access was more likely in secondary than in elementary schools (three-quarters versus under two-thirds); in more affluent than less affluent schools (78 percent versus 53 to 58 percent); and in schools with low to moderate minority enrollments, as compared with schools with high minority enrollments (65 to 72 percent versus 56 percent). (See appendix table 1-25.) As with computers, access to the Internet does not always translate into use by students and teachers, nor does it ensure effective use. Although close to two-thirds of U.S. schools could connect to the Internet, access was pos-

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[18] U.S. data on computer use are reported only for mathematics classes. Fourth grade teachers were not asked about computer use in science. The response rate for eighth grade science teachers in the United States was too low for estimates to be reliable.

Text table 1-3.
Percentage of students reporting that they have a computer at home, by country: 1994-95

Country	Grade 4	Grade 8	Country	Grade 4	Grade 8
Australia	63	73	Kuwait	66	53
Austria	61	59	Latvia	21	13
Belgium (Flemish-speaking)	–	67	Lithuania	–	42
Belgium (French-speaking)	–	60	Netherlands	80	85
Canada	52	61	New Zealand	53	60
Colombia	–	11	Norway	56	64
Cyprus	35	39	Portugal	34	39
Czech Republic	33	36	Romania	–	19
Denmark	–	76	Russia	–	35
England and Wales	88	89	Scotland	89	90
France	–	50	Singapore	44	49
Germany	–	71	Slovak Republic	–	31
Greece	23	29	Slovenia	43	47
Hong Kong	37	39	South Korea	23	39
Hungary	37	37	Spain	–	42
Iceland	81	77	Sweden	–	60
Iran	8	4	Switzerland	–	66
Ireland	79	78	Thailand	3	4
Israel	70	76	United States	56	59

– = did not participate in fourth grade assessment

SOURCES: A. Beaton, I. Mullis, M. Martin, E. Gonzalez, D. Kelly, and T. Smith, *Mathematics Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1996); and I. Mullis, M. Martin, A. Beaton, E. Gonzalez, D. Kelly, and T. Smith, *Mathematics Achievement in the Primary School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1997).

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sible from only 14 percent of instructional rooms (e.g., classrooms, computer labs, library media centers) according to recent surveys (NCES 1997a). (See figure 1-17.)

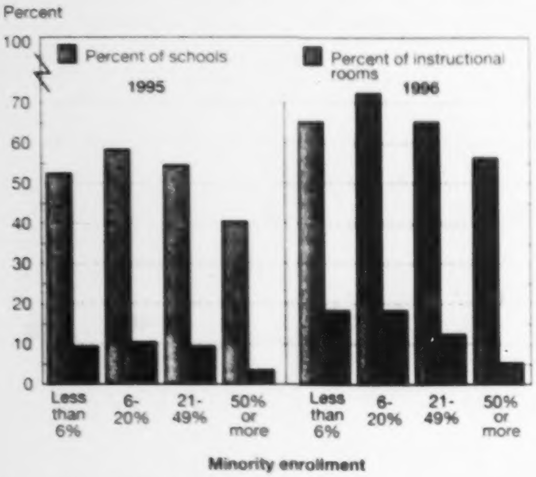
Teachers and the Profession of Teaching

The National Council of Teachers of Mathematics' standards and the National Research Council's science standards present new visions of what should be taught, as well as when and how it should be taught. Standards in both subjects call for teachers to introduce and develop topics that, in the past, were reserved for later grades and to orchestrate instruction in ways that are not commonly observed in today's classrooms. At present, few teachers possess both the knowledge of teaching and learning and the knowledge of content necessary to meet these expectations for the effective teaching of mathematics and science.

Teacher Preparation and Student Achievement

Until recently, attempts to link student achievement to teacher qualifications focused on degrees earned and major or minor fields of study. These attempts have not been altogether successful; few, if any, consistent effects were found. This was a sensible research strategy at the time because teacher certification requirements were specified in those terms. But more contemporary findings suggest that additional coursework in specific areas may not only increase teachers' knowledge of subject matter, but may also expand the range of teaching and learning approaches a teacher is likely to use in the classroom—and expand student achievement.

Figure 1-17.
Percentage of U.S. public schools and instructional rooms with Internet access, by proportion of minority enrollment



See appendix table 1-25.

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Recent studies are using more refined ways to measure teacher qualifications and, as a result, have established that the number and kind of courses taken by mathematics and science teachers do influence student performance. Higher student test scores have been related to teachers who have had more advanced courses in mathematics and science and in other educational areas. Taking additional coursework in unrelated subjects had no—or sometimes even a negative—effect on student learning (Monk 1994).

In addition, students whose teachers have completed more course credits in their field (and those with higher grade point averages) achieve at higher levels than other students. In a study conducted by Chaney (1995), teachers who had taken courses in mathematics at above calculus level coupled with courses in mathematics education were found to have students who less frequently scored in the lower achievement grouping and more often demonstrated advanced levels of performance. (See appendix table 1-26.) In addition, these better prepared teachers were more likely to expose their lower level mathematics students to college preparatory subjects such as algebra in regular mathematics classes (Chaney 1995).

Still other studies examining the knowledge base and preparation of teachers have identified important differences in instruction. Several of these studies showed that when covering topics on which they were well-prepared, teachers more often encouraged student questions and discussion; spent less time on unrelated topics; permitted discussion to move in new directions on the basis of student interests; and generally presented the topics in a more coherent, organized fashion. When covering unfamiliar topics, teachers discouraged active participation by students, kept discussion under tight rein, relied more on presentations than on student discourse, and spent more time on tangential issues such as study skills and cooperative effort (see, e.g., Carlsen 1991, and Smith and Neale 1991).

Coursework Preparation

An increasing number of states are requiring that teachers have a college major or a minimum number of credits in the subjects they plan to teach. Twenty-nine states now require, at least at the middle and high school levels, that teachers have a degree in a specific subject area other than education. Nine of these states also require this of elementary school teachers (CCSSO 1996). (See appendix table 1-20.)

As of the 1993/94 school year, 1 percent of elementary school teachers possessed a mathematics degree, 2 percent had a science degree, and only 5 or 6 percent more had either majored or minored in mathematics or science education in college. The vast majority of elementary school teachers earn college degrees in education rather than in specific disciplines or disciplinary areas of education. High school teachers were much more likely to possess mathematics and science degrees. Of high school mathematics teachers, 41 percent had earned a degree in mathematics compared with just 7 percent of middle school teachers. In science, 63 percent of high school, and 17 percent of middle school, science teachers possessed some form of science degree. (See text table 1-4.)

The professional associations have made specific recommendations for the preparation of mathematics and science teachers. (See "Are Teachers Knowledgeable About the Standards?") The NCTM standards recommend that middle school mathematics teachers take college courses in abstract algebra, geometry, calculus, probability and statistics, and applications of mathematics/problem solving. An even more detailed list of coursework is recommended for high school mathematics teachers (Weiss, Matti, and Smith 1994).

Many middle school mathematics teachers fall short of these recommendations. Only 7 percent of middle school mathematics teachers have taken courses in all of the areas recommended by the standards, and about one-third have taken none. High school teachers are generally better prepared. About one-third have completed courses in at least 9 of 10 recommended areas, and only 2 percent have completed just one course or none of the recommended coursework. Virtually all elementary school teachers have completed some courses in mathematics education or mathematics for elementary teachers: 42 percent have completed college algebra/trigonometry, or elementary functions, but only 12 percent have completed calculus (Weiss, Matti, and Smith 1994).

The National Science Teachers Association recommends that elementary school teachers have one course each in the biological, physical, and earth sciences as well as coursework in science education. Just about half of elementary teachers have satisfied this requirement. Middle school science teachers are encouraged to take at least two courses in each area as well as teacher training in their field (Weiss, Matti, and Smith 1994). Only 42 percent of middle school science teachers (grades 5 to 8) and 57 percent of junior high school (grades 7 to 9) science teachers meet the Association's recommendations in full. Recommended courses for the prospective high school teacher are quite detailed in each of the three areas of science, and there is a considerable range in the number of teachers meeting those recommendations. Less than half of earth science teachers, compared with 90 percent of biology teachers, had taken six or more credits in their respective subject areas (Weiss, Matti, and Smith 1994).

Teachers' Views of Teaching and Learning

How teachers go about their work in classrooms depends to some extent on their views about the nature of their academic disciplines and about teaching and learning in their fields. Research in the last 10 years supports this claim (Dwyer 1993a and 1993b). Teachers who see science as a static collection of facts tend toward instructional approaches that rely on "teacher-talk" and direction, and on student practice and memorization. Teachers who see science as a process of empirical discovery are more comfortable with hands-on learning and open-ended tasks (Carlsen 1991, and Smith and Neale 1991). Others have made similar observations about the views and practices of mathematics teachers (Dossey 1992 and Thompson 1992).

The majority of teachers have fairly practical views of mathematics and science. Close to 80 percent of teachers in both subjects see their fields as providing "formal ways of representing the real world," and close to 90 percent as a "structured guide for addressing real situations." Only 31 percent of mathematics teachers and 18 percent of science teachers view their subject as an abstract conceptual system.

A number of teachers have views that run counter to the general directions set by standards. Close to 80 percent of mathematics teachers believe that some students have a natural talent for mathematics while others do not, and 35 percent think that mathematics should be learned as a set of algorithms or rules. In science, teachers sometimes hold similar views. Almost two-thirds of science teachers believe that some students have a natural talent for science and others do not. About three-quarters believe that students should be given prescriptive and sequential directions for doing experiments;

Text table 1-4.
Percentage of teachers with majors and minors in science/mathematics and science/mathematics education: 1993

	Science teachers			Mathematics teachers		
Major/minor	Grades 1-4	Grades 5-8	Grades 9-12	Grades 1-4	Grades 5-8	Grades 9-12
Undergraduate major in science/mathematics	2	17	63	1	7	41
Undergraduate or graduate major in science/science education or mathematics/mathematics education	3	21	72	1	11	63
Undergraduate or graduate major or minor in science/science education or mathematics/mathematics education	7	32	94	7	18	81

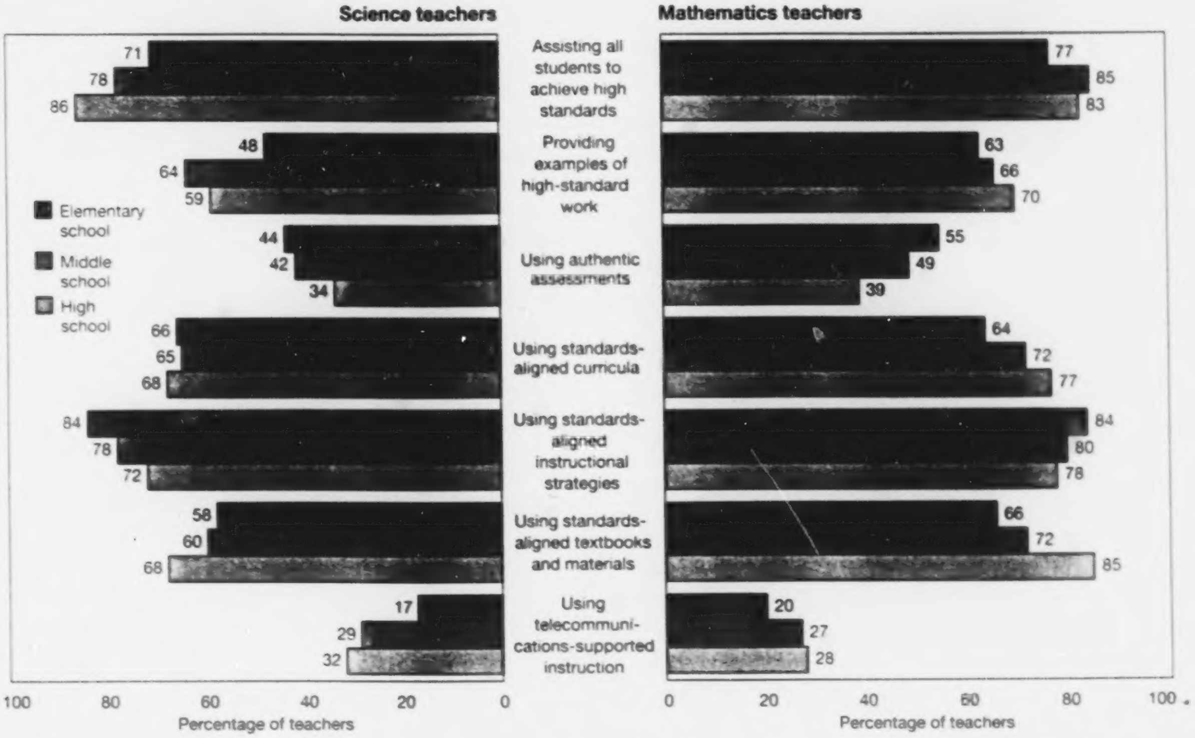
SOURCE: I.R. Weiss, M.C. Matti, and P.S. Smith, *Report of the 1993 National Survey of Science and Mathematics Education* (Chapel Hill, NC: Horizon Research, Inc., 1994).

Are Teachers Knowledgeable About the Standards?

In a 1995 survey of teachers, 85 percent of eighth grade mathematics teachers reported being "fairly" or "very" familiar with the *Curriculum and Evaluation Standards for School Mathematics* of the National Council of Teachers of Mathematics. Approximately 26 percent of eighth grade science teachers reported being "very" or "fairly" familiar with *Benchmarks for Science Literacy* of the American Association for the Advancement of Science. The numbers might have been higher if teachers had been asked about standards published by the National Science Teachers Association, an organization to which many science teachers belong (Williams et al. 1997). However, it should be noted that neither of these sets of science standards realized the same levels of visibility and acceptance by the science teaching community as was true of the mathematics standards within the mathematics teaching community.

There are indications that U.S. teachers believe they are implementing some aspects of standards-based instruction. A 1996 survey asked teachers to report on the kind of reform activities they are implementing in their classrooms. The seven-item list of activities included assisting students to reach high standards, using curriculum materials aligned with standards, and using authentic assessments. (See figure 1-18.) Except for using authentic assessments and telecommunications to support instruction, in the majority of cases, mathematics and science teachers at all three levels of schooling believed they were implementing each of the activities included in the survey (NCES 1997d).

Figure 1-18.
Percentage of science and mathematics teachers implementing reform activities in their classes: 1996



SOURCE: National Center for Education Statistics, *Status of Education Reform in Public Elementary and Secondary Schools: Teachers' Perspectives* (Washington, DC: U.S. Department of Education, 1997), forthcoming.

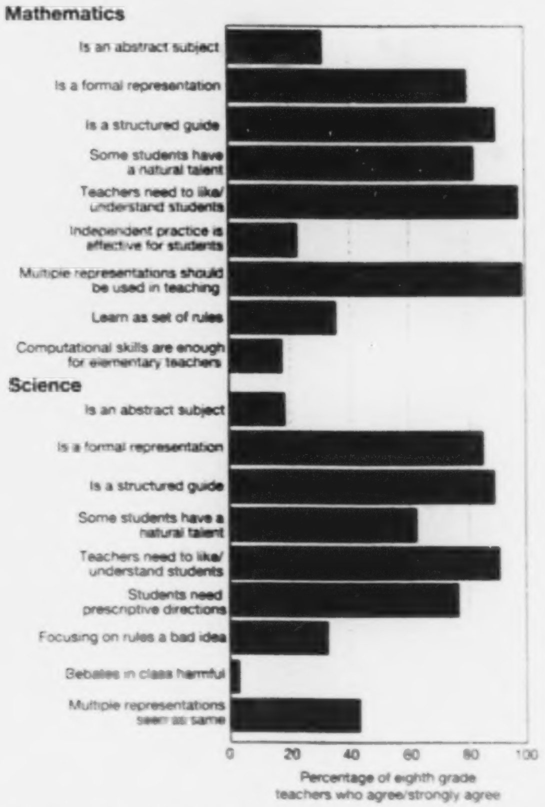
Science & Engineering Indicators – 1998

only 32 percent thought focusing on rules might be a bad idea. (See figure 1-19.)

There is substantial agreement between mathematics and science teachers on the aptitudes and skills students need to succeed in learning mathematics and science. Over 80 percent of mathematics and science teachers consider it very important for students to understand concepts, to understand how the subjects are used in the real world, and to be able to support their results and conclusions.

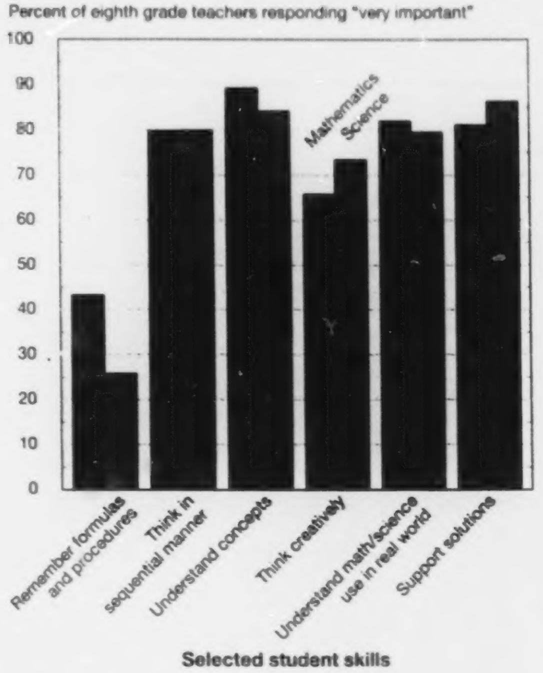
There are some areas of difference in these views. Fewer mathematics teachers (65 percent) than science teachers (73 percent) consider creative thinking very important. However, the biggest difference in views centers on the importance of students remembering formulas and procedures. Over 40 percent of mathematics teachers believe that it is important for students to memorize formulas, compared with 26 percent of science teachers. (See figure 1-20.)

Figure 1-19.
Teacher beliefs about the nature and teaching of mathematics and science: 1994-95



See appendix table 1-18. *Science & Engineering Indicators – 1998*

Figure 1-20.
Teacher perceptions of student skills required for success in mathematics and science: 1994-95



See appendix table 1-19.
Science & Engineering Indicators – 1998

Out-of-Field Teaching

Information about the academic preparation of the teaching force and their views and attitudes toward teaching and learning do not tell the complete story of teachers' qualifications. All too frequently, teachers are assigned to classes outside their fields (Ingersoll 1996). The problem is particularly acute in mathematics. In the 1990-91 school year, students were less likely to have a qualified teacher in mathematics than in any other core subject. About 27 percent of students in grades 7 to 12 had a mathematics teacher without at least a minor in mathematics or mathematics education compared with 21 percent in English, 17 percent in science, and 13 percent in social studies. Out-of-field teaching is more common at middle and junior high schools than in senior high schools. In 1991, 32 percent of students in 7th grade science classes had teachers without a major or minor in science or science education, while only 13 percent of 12th graders did. (See appendix table 1-24.)

There are large differences across states in the proportions of mathematics and science teachers who have degrees in these subjects. The percentage of secondary mathematics teachers with a major in mathematics ranges from under 45 percent in Alaska, Delaware, and Washington to over 80 percent in Pennsylvania and the District of Columbia. Similarly, fewer than half of secondary science teachers in Nevada and Louisiana majored in science in college compared with 80 or more percent in 10 states (Blank and Gruebel 1995).

There are also equity issues involved with out-of-field teaching which is more prevalent in high-poverty schools, in low-achieving classes, and in low-track classes (Chaney 1995; Gamoran 1986; and Oakes, Gamoran, and Page 1992). For example, more than one-quarter of students enrolled in secondary school science classes in which students were judged to be low achieving had a teacher without at least a minor in science or science education, compared with fewer than 1 in 10 students in high-achieving classes. Thirty-six percent of students in classes with high minority enrollments had a mathematics teacher without a major or minor in mathematics or mathematics education, compared with 23 percent of students in low minority classes. In addition, students who attend school in high-poverty areas are much more likely to have mathematics and science teachers without at least a minor in these fields than students attending schools in low-poverty areas. (See figure 1-21.) In effect, students who need the most support are left with the teachers least qualified to help them (Darling-Hammond 1994a; Oakes 1990; and Weiss, Matti, and Smith 1994).

Reform of the Teaching Profession

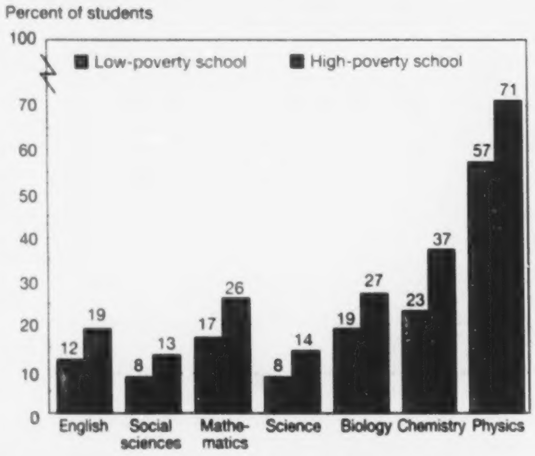
Many efforts in the last decade to bring about systemic, standards-based changes in schools have focused on the professionalization of teaching. The logic underlying this approach is that upgrading the profession will increase teachers' commitment and motivation. This will in turn result, it is believed, in better teaching, with the final outcome being improved student learning. A variety of proposals have been offered for improving the status and professional credentialing of teachers. The most ambitious of these proposals seek changes in how teachers are prepared, licensed, and supported throughout their careers (see, for example, Carnegie Forum on Education and the Economy 1986, and National Commission on Teaching and America's Future 1996).

The National Commission on Teaching and America's Future, for example, recommends:

- organizing teacher education and professional development programs around the standards;
- developing extended graduate level teaching programs that offer year-long internships, similar to those offered in the medical profession, to provide closely supervised practice that is tied to coursework; and
- creating stable, high-quality professional development services to support teachers.

Efforts are under way to bring about each of these changes. Some of these initiatives have focused primarily on teacher preparation. The Holmes Group, which was formed by college deans of education, proposed that prospective teachers be required to devote four years of undergraduate study to academic content in their chosen major, and that professional preparation in teaching be postponed to a fifth or sixth year (Holmes Group 1986). Year-long internships, two-year induction periods, and professional development schools are all variations on this basic idea aimed at providing prospective teachers with both better academic preparation and more classroom experience before licensing.

Figure 1-21.
Percentage of public secondary students taught by teachers without at least a minor in the field, by school poverty enrollment: 1993-94



NOTE: In a low-poverty school, 0 to 5 percent of students are eligible for free or reduced-price lunch; in a high-poverty school, 41 to 100 percent of students are eligible for free or reduced-price lunch. The percentages for biology, chemistry, and physics represent students taught by teachers without at least a minor in those particular fields.

SOURCE: National Center for Education Statistics, *The Condition of Education 1996*, NCES 96-304 (Washington, DC: U.S. Department of Education, 1996).

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Other efforts have focused on development of standards to guide the profession. The National Board for Professional Teaching Standards has developed standards for accomplished teaching, created performance-based certification exams to identify accomplished teachers, and established a professional board to oversee operation of the system (NBPTS 1991). The Interstate New Teacher Assessment and Support Consortium (INTASC), which was formed by a consortium of state education agencies, higher education institutions, and national educational organizations, has focused on the other end of the continuum: new teachers. INTASC has begun to develop standards and performance-based assessments useful for judging competent entry-level teaching and for guiding the professional development of early career teachers (INTASC 1991).

Both sets of teachers' standards are compatible with each other, and both are directly linked to the national standards for student performance in specific content areas. The standards for new teachers developed by INTASC have been adopted or adapted for use by 14 states and are being used in several additional states as a basis for evaluating their systems for licensing (INTASC 1994).

Policy efforts also have been initiated to infuse standards-based conceptions of teacher preparation into higher education and teacher training institutions. Many educators view the process of program accreditation as the most effective lever for bringing about desired changes. The National Council for the Accreditation of Teacher Education, which has accredited teacher education programs for many years in cooperation with state agencies, has taken steps in this direction. Recently, it has incorporated performance standards developed by the aforementioned INTASC in the program approval process (Darling-Hammond 1994a).

Conclusion

The central question motivating this chapter is whether the K-12 education system in the United States is doing a good job of providing students with a solid foundation in mathematics and science in order to prepare them for work or continuing study, or simply to be literate members of society.

The answer depends on the perspective taken. From the perspective of curriculum, national and cross-national studies give somewhat different answers. National trend studies suggest that U.S. schools are doing a better job of addressing long-standing inequities in the mathematics and science preparation provided to students in different demographic groups. Compared with the late 1970s and early 1980s, higher proportions of male and female students now complete the core college preparatory courses in mathematics and science, and more black and Hispanic students do so as well. On the other hand, as recently as 1994, a significantly larger fraction of white than black and Hispanic students completed advanced courses in mathematics and science, and more male than female students completed physics. Therefore, there are still substantial inequities to be overcome.

International comparisons suggest that U.S. curricula are lacking in depth and focus. The content of the science curriculum is within the international norms for grades 4, 8, and 12. But relative to science curriculum documents and textbooks in other countries, U.S. schools provide too much repetition, too many topics to be learned, and too little coverage of core science topics.

These limitations are even more characteristic of the mathematics curriculum. There are indications as well that at least the eighth grade mathematics curriculum is pitched at a lower level than in other countries. U.S. curriculum guides and textbooks emphasize topics related to whole numbers and fractions while in most other countries, students are studying more topics in geometry and algebra. Cross-national observations of what takes place in eighth grade mathematics classrooms confirm these findings. Lesson goals and the activities provided to support those goals reflect quite limited cognitive expectations. More often than not, the goal is for students to learn specific skills rather than develop a deep understanding of mathematics.

From the perspective of achievement, national and cross-national studies again point to somewhat different conclusions. Following declines in the 1970s, the performance of U.S. students improved in basic skill areas. Nine- and 13-year-olds are scoring higher on mathematics and science assessments than they did in 1973, while 17-year-olds' performance in 1996 was about the same as in 1973. Although progress has not been substantial in the 1990s, U.S. students have lost no ground. Achievement also improved from 1990 to 1996 in mathematics assessments geared to national mathematics standards. And analyses of the performance of girls and boys in the 1990s show few meaningful differences.

But students of different demographic backgrounds are not achieving at the same levels. Asian Americans and Pacific Islanders and white students outperformed black, Hispanic, and Native American students—even when comparisons correct for the disparities in the courses students have taken. Standards-referenced science assessments introduced in 1996 are too different from earlier tests to permit comparisons with earlier years. But the same pattern of ethnic differences was observed in science as in mathematics.

Findings from the most recent international studies of achievement are mixed, depending on subject matter and grade. Better performance was demonstrated by U.S. fourth grade than eighth grade students when compared with other countries. They scored above the international average in mathematics and well above the international average in science. Eighth grade students performed above the international average in science but well below the international average in mathematics. Because of differences in the ways earlier international comparisons were conducted, it is difficult to tell if U.S. students are performing comparatively better or worse than they did in previous years. Although the relative standing of U.S. fourth grade students in science has gone up compared with earlier studies, it cannot be said definitively that this represents a real change in standing.

Returning to the original question: what do these findings suggest about the progress and quality of U.S. education? First, they show that the mathematics and science education of students is improving somewhat in terms of equity and excellence—the dual goal of educational reforms. Second, there is much room for improvement, and we are still far from reaching our national goal of being first in the world in mathematics and science. Third, students are not yet performing at the levels of expectation recommended by the mathematics and science standards. Fourth, the curricula could better define and focus on core content in mathematics and science as recommended by the standards. And fifth, teachers could better help students develop a genuine understanding of mathematics and science by engaging them in active tasks that challenge their intellectual capabilities. On the whole, although progress has been made, our schools and school districts will have to do much more if students are to be well-prepared for a future that demands that we, as a nation, have a citizenry solidly grounded in mathematics and science.

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Chapter 2
Higher Education in Science and Engineering

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Highlights

WORLDWIDE INCREASE IN S&E EDUCATIONAL CAPABILITIES

- **From the mid-1980s to the mid-1990s, the number of first university degrees in higher education in science and engineering (S&E) increased rapidly in Asia and Europe, and slowly in North America.** During this period, first university degrees in S&E grew at an average annual rate of 4.8 percent among 16 European countries, at 4.1 percent among 6 Asian countries, and at 1.3 percent among North American countries.
- **The increase in S&E degree production in Asia is driven by expanding access to higher education for large or growing populations.** Developing countries such as India and China have large populations in their college-age cohorts and increasing participation rates in postsecondary education. The increase in S&E degree production in Europe is driven by expanding access to higher education in the face of a declining student population.
- **A higher percentage of the college-age population in selected Asian countries than in Europe or North America earns university degrees in the natural sciences and engineering (NS&E).** In Japan, Singapore, South Korea, and Taiwan, between 6 and 7 percent of 24-year-olds earn NS&E degrees, compared to between 4 and 5 percent of 24-year-olds in Western Europe and North America.
- **In Europe, Asia, and North America, women have been particularly successful in earning degrees in the natural and social sciences.** By 1995, women earned close to half of the natural science degrees in higher education institutions in several countries, including the United Kingdom, Italy, the United States, and South Korea. Women in the three regions have also earned the majority of first university degrees in the social sciences, but are considerably less likely to earn degrees in engineering.

CHARACTERISTICS OF U.S. HIGHER EDUCATION INSTITUTIONS

- **The United States has a large and diversified set of institutions of higher education that provides a college or university education to over one-third of the U.S. college-age population.** The country has one of the most open education systems in the world. Other countries are also broadening educational access and expanding their graduate programs, particularly in S&E fields.
- **After several decades of continual and rapid expansion of higher education in the United States, enrollment fell for the first time in 1993; it has continued to decline each year since.** This decline is partially based on demographics: the U.S. college-age population declined from 22 million in 1980 to 17 million in 1995. The decline in the college-age population was offset for over a decade by expanded access to higher education for all subpopulations, particularly women and minorities, and enrollment by larger numbers of older students. By 1993, however, overall enrollment began to decline.

UNDERGRADUATE S&E STUDENTS AND DEGREES IN THE UNITED STATES

- **The trend of increasing enrollment of underrepresented minority students in undergraduate programs has persisted for over a decade and accelerated in the 1990s.** Black enrollment increased 3.6 percent annually in the 1990s, reaching 1.3 million in 1995. Hispanic enrollment in higher education increased at an even faster rate during this period (7.1 percent annually).
- **In 1995, at the community college level, over half (57.8 percent) of the enrollment in mathematics classes was for remedial level courses.** In 1970, remedial courses in community colleges accounted for about a third of all mathematics courses.
- **The percentage of freshmen in four-year institutions reporting a need for remedial work in mathematics and science has remained high, particularly for women and minorities.** In 1995, of those freshmen planning to major in science or engineering, over 16 percent of the males and over 26 percent of the females thought they would need remedial work in mathematics. Among freshman students from underrepresented minority groups planning to major in science or engineering, over 38 percent reported that they would need remedial work in math.
- **The number of earned bachelor's degrees in S&E from U.S. institutions has been increasing for over a decade, but trends differ by field.** The number of natural science degrees increased 7.7 percent annually from 1990 to 1995, with stronger than average growth in the biological and environmental sciences, but only modest (2 percent) growth in the physical sciences. Attraction to the computer sciences dropped precipitously from 1986 to 1991, followed by slight decreases to 1995. The number of social science degrees awarded, after record growth between 1986 and 1992 (averaging 6 percent annually), has remained stable for the last four years. Engineering degrees, whose numbers also peaked in 1986, declined until 1991 and then stabilized.
- **In 1995, for the country as a whole, over 5 percent of the college-age population had completed a bachelor's degree in an NS&E field.** But in that same year, only about 2 percent of black and Hispanic youth earned a bachelor's degree in an NS&E field. Asian Americans, representing only 4 percent of the U.S. population, have considerably higher than average participation rates: over 12 percent earned an NS&E degree. Low participation rates for blacks and Hispanics changed little throughout the 1980s, although they improved somewhat in the 1990s.

GRADUATE S&E STUDENTS AND DEGREES IN THE UNITED STATES

- **Enrollment in U.S. graduate S&E programs grew for almost 20 years, reached a peak of almost 440,000 students in 1993, and then began to shrink.** The decline in enrollment has averaged 1 percent annually. Fewer students enrolling in engineering, mathematics, and the computer sciences account for most of this decline.

- **While women continued a decade-long trend of increased enrollment in graduate S&E programs in 1993, enrollment figures for U.S. white males began a downward trend.** In 1977, women represented only one-quarter of S&E graduate enrollment; by 1995, they accounted for 38 percent of enrollment.

- **Progress for underrepresented minorities in S&E graduate enrollment has been very modest.** In 1975, they accounted for 3.7 percent of S&E graduate enrollment; by 1995, they accounted for 5.0 percent.

- **In 1992, foreign graduate students reversed their decade-long trend of increased S&E enrollment in U.S. institutions.** They decreased their enrollment each year since then. From 1983 to 1992, the number of foreign graduate students increased over 5 percent annually. From 1992 to 1995, their numbers decreased more than 3 percent annually.

- **The number of S&E degrees awarded in the United States at the master's level increased throughout the 1980s, with even stronger growth in the 1990s.** The recent growth is mainly accounted for by rising numbers of earned degrees in the social sciences and engineering, with relatively stable numbers in the natural sciences, mathematics, and computer sciences.

- **The proportion of U.S. master's degrees earned by females increased considerably in the last two decades—not only in the natural sciences, but in engineering as well.** In 1975, females earned 21.1 percent of the natural science degrees at the master's level and 2.5 percent of the engineering degrees. By 1995, females accounted for 41.0 percent of natural science degrees and 16.2 percent of engineering degrees.

- **Asian Americans earned an increasing number of S&E master's degrees, while the number of such degrees awarded to underrepresented minorities grew only slightly.** The number of S&E master's degrees awarded to Asian Americans grew especially in engineering, mathematics, and the computer sciences. The number of S&E master's degrees obtained by blacks grew modestly in most fields, although there was strong growth in the social sciences. Hispanics also earned a modestly increasing number of degrees in the social sciences, as well as in engineering.

- **The number of doctoral degrees in engineering, mathematics, and the computer sciences nearly doubled from 1985 to 1995.** Natural science fields—particularly the biological sciences—contributed to the rising number of degrees, with a 30 percent increase.

- **Women accounted for an increasing proportion of S&E doctoral degrees, while underrepresented minorities showed only a slight increase.** By 1995, females earned almost half of the doctoral degrees in the social sciences, 38 percent in the biological sciences, and almost 12 percent in engineering. Underrepresented minorities received less than 5 percent of all S&E doctorates awarded in 1995, up slightly from 3 percent in 1977.

- **In the past decade, foreign students have accounted for the large growth in S&E doctoral awards in U.S. universities.** The number of foreign doctoral recipients in U.S. universities doubled in S&E fields from over 5,000 in 1986 to over 10,000 in 1995—an 8.2 percent average annual increase. In contrast, the rate of increase in doctoral degrees to U.S. citizens averaged only 1.9 percent annually.

- **The proportion of foreign doctoral recipients planning to remain in the United States has increased: for the 1992-96 period, over 68 percent planned to locate in the United States, and nearly 44 percent had firm offers to do so.** Stay rates differ considerably by place of origin. In 1996, 57 percent of the U.S. S&E doctoral recipients from China and 59 percent of those from India choose to accept employment in the United States. In contrast, only a small percentage of 1996 doctoral recipients from South Korea and Taiwan (24 and 28 percent, respectively) accepted employment offers in the United States.

- **From 1990 to 1994, U.S. universities provided slightly more than half of their postdoctoral appointments to non-U.S. citizens.** However, like the recent decline of foreign graduate enrollments in S&E in U.S. universities, there has been a slightly smaller proportion of foreign postdoctoral appointments and a slightly increasing number of appointments to U.S. citizens, particularly in the sciences. Foreign postdoctoral recipients still receive the majority of such research positions within U.S. universities in engineering.

- **One indicator of mobility of S&E personnel in the world is the proportion of foreign-born faculty in U.S. higher education.** In 1993, foreign-born faculty in U.S. higher education accounted for 37 percent of the engineering professors and 27 percent of the mathematics and computer science teachers. These faculty are mainly from Asia and Europe, with the largest numbers coming from India, China, the United Kingdom, Taiwan, Canada, and South Korea.

INTERNATIONAL COMPARISONS OF S&E TRAINING

- **Europe leads North America and Asia in S&E doctoral degree production.** In 1995, doctoral degrees awarded in S&E fields by Western and Eastern European institutions totaled 45,647—about 60 percent higher than the North American level and almost three times as many as the number recorded for Asian countries.
- **While graduate S&E programs are expanding rapidly in Asia, women have not yet entered those programs in large numbers.** Women still earn only a small fraction of the doctoral S&E degrees issued in Asia. In 1995, women in South Korea and Taiwan earned only 7 and 9 percent, respectively, of total S&E degrees at the doctoral level.

Introduction

Chapter Overview

Scientific discoveries, technological innovation, and the information revolution had a tremendous influence on U.S. society and the global economy in the late 20th century. These forces will have still greater roles in shaping the emerging knowledge society that will mature worldwide in the 21st century. The U.S. higher education system has facilitated this knowledge explosion and contributed, directly and indirectly, to the worldwide diffusion of science and engineering (S&E) knowledge. Consequently, encouragement of S&E education is a key element of the economic growth strategies of many countries around the world.

This chapter on higher education in S&E discusses trends that demonstrate the increasing globalization of S&E capabilities. At the undergraduate level, the globalization of science and technology has domestic implications for further openness in access to higher education in S&E fields for women and minorities, who will comprise the majority of the labor force in the 21st century. The increasing global capabilities for graduate S&E education have implications for the large international component of U.S. graduate S&E programs. This chapter includes indicators of the increase in capabilities for S&E education at the bachelor's and doctoral levels in three world regions: Asia, Europe, and North America. It also includes domestic indicators of current achievement in earning S&E degrees, both at the national level and for women and minorities.

Chapter Organization

This chapter begins and ends with international comparisons that put U.S. higher education indicators in a broader context. The comparisons at the chapter beginning are at the bachelor's level (referred to internationally as "first university degrees"), while those at the end are at the doctoral level. The initial international indicators relate to the number of S&E degrees: the growth rate over time of first university degrees, the proportion of S&E degrees produced among regions, participation rates of college-age cohorts in S&E degrees, differences in participation rates by sex, and the ratio of S&E degrees to total first university degrees by country.

The main body of the chapter focuses on U.S. higher education in science and engineering, including institutions, enrollment, and degrees at all levels. To a greater extent than is possible with the international indicators, domestic data illustrate trends in disaggregated fields, show coursetaking behavior at the undergraduate level, and note achievement by women and minorities. The following domestic indicators are disaggregated by race and sex: trends in enrollments, choice of S&E majors, need for remedial work in mathematics and science, participation rates in S&E degrees, and earned degrees at all levels.

Changes in the contributions of international students and faculty are explored in indicators on foreign doctoral students and stay rates in the United States of foreign doctoral recipients, the growth and change of postdoctoral appointments, foreign faculty in U.S. higher education, and reverse flows of U.S.-trained scientists and engineers to Asia.

The final chapter sections present science and technology indicators relating to international mobility. These include international comparisons of foreign student enrollment and comparison of doctoral S&E degree production in three world regions.

Note that trends are presented in terms of both S&E and the natural sciences and engineering (NS&E) throughout this chapter. These designate different aggregations of fields. S&E is the more inclusive term, including all fields; NS&E excludes social and behavioral sciences.[1] Both aggregations are included because trends differ among S&E and NS&E, particularly for women and minority groups (e.g., they are relatively better represented in the social and behavioral sciences). In addition, to make international comparisons more comparable in scope, NS&E is frequently used.

Worldwide Increase in S&E Educational Capabilities

In each country, a number of factors drive student participation in science and engineering. Among these are demographics (the number of college-age students), organizational aspects of the university system (how open—accessible—the system is), how the secondary education system dovetails into higher education, as well as the incentives for studying and staying in S&E as opposed to entering directly into the workforce. These factors combine in different ways in each country to influence the number of S&E students.

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[1] The natural sciences comprise the physical, chemical, biological, agricultural, earth, atmospheric, and oceanographic sciences, as well as mathematics and the computer sciences.

First University Degrees[2]

From the mid-1980s to the late 1990s, the number of first university degrees in science and engineering increased rapidly in Asia and Europe and slowly in North America. In this period, first university degrees in S&E grew at an average annual rate of 4.8 percent among 16 European countries, at 4.1 percent among 6 Asian countries, and at 1.3 percent among North American countries.[3] When considering only NS&E degrees, the North American degrees declined at an average annual rate of just under 1 percent (NSF 1993 and NSF 1996a), while the European and Asian degrees increased over 4 percent.

In 1995, more than 2.1 million students in these three regions earned a first university degree in science or engineering, up from 1.6 million in 1992.[4] (See "Degree Data Available for Asia, Europe, and North America.") These 2.1 million degrees were evenly divided among the major fields: approximately 765,000 were earned in the natural sciences, 643,000 in the social sciences, and 739,000 in engineering. (See text table 2-1.)

By 1995, within the Asian region, the number of first university degrees in the natural sciences rose to over 300,000—almost as many as the number of such degrees earned in the European region, and about twice the number earned in the North American region. Within engineering, selected Asian countries produced over 343,000 degrees, 21 percent higher than the number of such degrees in Europe (including Russia), and more than three times the number earned in the North American region. (See figure 2-1, text table 2-1, and appendix table 2-1.)

Degree Data Available for Asia, Europe, and North America

Data availability differs among the countries of these three regions. Trend data on degrees earned in broad S&E fields have been developed for 6 Asian economies—China, India, Japan, Singapore, South Korea, and Taiwan; 16 Western European countries—Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom; and 3 North American countries—Canada, Mexico, and the United States. (See NSF 1993 and NSF 1996a.) Recent degree data covering one year only (1993 or 1994), for selected Central and Eastern European countries and Russia, were obtained from the Organisation for Economic Co-operation and Development (1996). In addition, more of Asia's developing countries—including Indonesia, Malaysia, and Thailand—have begun collecting and reporting their national education statistics to UNESCO's annual survey, providing a more complete picture of the Asian region.

Asia

Trend data from selected Asian countries show that for China, India, Japan, South Korea, Singapore, and Taiwan, the number of first university degrees in science and engineering fields increased greatly. Between 1975 and 1995, the total

Text table 2-1.
First university degrees in S&E, by region: 1995 or most recent year

Field	Three-region total	Asia	Europe	North America
First university degrees, all fields	5,208,205	2,043,677	1,713,423	1,451,105
Science & engineering	2,146,648	926,426	732,263	487,959
Natural sciences	764,820	301,877	309,837	153,106
Social sciences	642,777	280,775	138,896	223,106
Engineering	739,051	343,774	283,530	111,747

NOTES: The requirements for first university degrees in S&E fields are not comparable across or even within the countries included in these three regions, particularly for European universities. For example, Germany includes both university degrees (with an average duration of 7 years) and *Fachhochschulen* degrees (polytechnics of 4.5 years' average duration) as first university degrees (level 6 in UNESCO classification). Work has been under way for several years at UNESCO, EUROSTAT, and the U.S. Department of Education to refine the levels of higher education for better comparability across countries. See, for example, U.S. Department of Education and National Science Foundation, *Mapping the World of Education: The Comparative Database System (CDS)* (Washington, DC: 1994). A new UNESCO survey will be designed and implemented by the end of this decade. See appendix table 2-1 for countries included in each region.

See appendix table 2-1.

Science & Engineering Indicators – 1998

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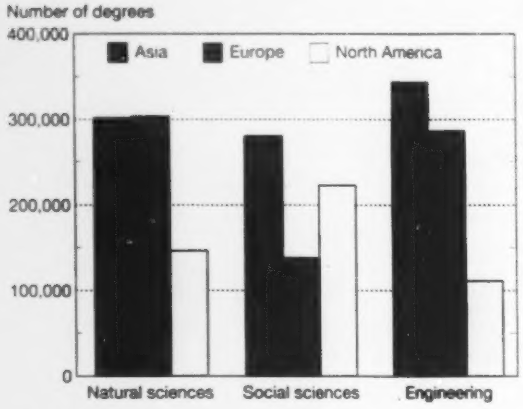
[2] Data in this section are taken primarily from the National Science Foundation, Science Resources Studies Division, Global Database on Human Resources for Science.

[3] A first university degree refers to completion of an undergraduate postsecondary degree program. These degrees are classified as level 6 in the International Standard Classification of Education, although individual countries use different names for the first terminal degree: e.g., *laureata* in Italy, *diplome* in Germany, *maitrise* in France, and bachelor's degree in Asian countries and the United States.

[4] Data were available from fewer countries for the 1992 regional totals. The 1995 European data include some Eastern European countries as well as Russia. (See appendix table 2-1.) See NSB (1996), appendix table 2-1, for countries included in 1992 regional totals.

Figure 2-1.
First university degrees in S&E, by world region: 1995 or most recent year



See appendix table 2-1. *Science & Engineering Indicators – 1998*

number of degrees in the natural sciences earned by students from these countries nearly doubled, while those in engineering more than tripled. (See NSF 1993 and appendix table 2-2.) In the last decade, the average annual growth rate in earned NS&E degrees in Asia was 4.2 percent. In contrast, in the North American region, the number of NS&E degrees declined at an average annual rate of 0.9 percent from 1986 to 1994. (See "Undergraduate S&E Students and Degrees in the United States" for further information on U.S. degree trends.)

The biggest increase in NS&E degrees in the Asian region came as a result of China reopening its universities and expanding its institutions of higher education in the 1980s. (See "Growth in Institutions of Higher Education in Asia.") From 1985 to 1995, earned degrees in the natural sciences rose from 28,000 to over 54,000; engineering degrees rose from 73,000 to almost 150,000. China has a strong commitment to higher education in the natural sciences (stressing the applied side of chemistry, physics, and biology); in 1995 it produced more than twice as many bachelor's degrees in these fields as did Japan. (See appendix table 2-2.)

China has the largest number of NS&E first university degree recipients at 203,238, followed by India at 176,036, and Japan at 127,971. However, with the large populations of China and India, the number of earned degrees represents a relatively small proportion of the college-age cohort. (See "Increasing Participation Rates in NS&E Degrees" later in this chapter and appendix table 2-1.)

China's rapid expansion of S&E degrees is partly explained by demography (its 20- to 24-year-old population equals 100 million) and partly by a national policy to extend higher education—particularly in science and engineering—in support of national economic development.

Europe

The increase in the number of S&E degrees awarded by higher education institutions in European countries is also noteworthy. (See "Growth in Institutions of Higher Education in Europe.") From 1975 to 1995, the Western European countries[5] collectively more than doubled their annual production of first university degrees in S&E. The number of natural science degrees increased from approximately 56,000 in 1975 to more than 150,000 in 1995. The number of social science degrees increased from approximately 50,000 in 1975 to over 80,000 in 1995. And the number of engineering degrees rose from 51,000 in 1975 to more than 137,000 in 1995. (See NSF 1996a and appendix table 2-1.)

The European expansion of higher education in science and engineering, and heavy investments in research and development (R&D), underpin a broader effort to maintain and enhance Europe's economic vitality through the European Union (EU). The EU is attempting to integrate the S&E research community and make the region's high concentration of science resources even more productive in order to increase competitiveness at the European and global levels (NSF 1996a).

Germany, France, and the United Kingdom account for most of this expansion of higher education; students from these three countries earned more than 60 percent of the first university degrees awarded in NS&E in Europe. The United Kingdom democratized its access to higher education through curricular reform of upper secondary education, providing the academic background for more students to continue in school past 16 years of age, with increased options to study science and subsequently enter the university. These reforms resulted in a significant increase in the number of NS&E degrees earned. Further, the number of U.K. degrees sharply increased in 1992 due to the reclassification of colleges and polytechnics as universities. In addition to a gradual expansion of higher education, a much larger number of engineering degrees in Germany resulted from the 1989 reunification of the former West Germany with the former East Germany, which—like many Central and Eastern European countries—had focused much of its higher education on engineering. (See NSF 1996a and appendix table 2-1.)

North America

Trend data on Canada, Mexico, and the United States show a decline in earned undergraduate degrees in NS&E from 1986 to 1994.[6] This decline is partly accounted for by changes in the demographics of the United States and Canada: specifically, the decline in college-age population that began in the mid-1980s. (See appendix table 2-3.) Initially, this downturn in the college-age cohort was offset by increasing access to higher education among all subpopulations. However, this broader access and increased enrollment in higher education did not result in larger numbers of bachelor's degree

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[5] Western European countries are those within the European Union and the European Free Trade Association. (See appendix table 2-1.)

[6] Data are from NSF (1997a), unpublished tabulations.

Growth in Institutions of Higher Education in Asia

The expansion of higher education institutions in Asia, particularly for graduate programs, has been financed by government (Japan), by industry (South Korea), and through international loans (China).

Japan. Japan greatly expanded its institutions of higher education in the 1950s. By 1955, there were over 100 public institutions, including both local and national universities. The number of public institutions has not significantly increased since then. In all, 25 national universities and 15 local universities have been opened in the last 40 years. In contrast, the number of private institutions has increased rapidly in the last few decades, reaching over 400 in 1995, and accounting for around 75 percent of all higher education institutions (Monbusho 1995). National universities, however, dominate in the production of doctoral degrees, accounting for 85 percent of NS&E degrees (Monbusho 1995).

About 30 of Japan's national universities are considered research universities. In the 1970s, the government Ministry of Education, Science, and Culture began building national inter-university research institutes open to all university researchers. These provide large-scale, well-equipped research facilities that can be used for international collaboration in specific fields. The first of these inter-university research institutes was the National Laboratory for Higher Energy Physics. These institutes, now numbering 15, have the same status as national universities (Monbusho 1995).

The main science funding agencies in Japan have sharply increased the amount of competitive research funding to universities to improve research facilities and personnel. About a half-dozen research institutes have received large five-year infusions of funds to enable them to become centers of excellence in specialized fields—e.g., brain research, material science, and econometrics (NSF 1997c).

South Korea. The most prestigious institutes of higher education in South Korea are those few national universities that survived the 1905-45 Japanese occupation. However, a substantial network of new higher educational institutions was created after the Korean War, consisting of 134 colleges and universities, and 152 junior colleges. The latter play a key role in the education of scientists and engineers. In fact, much of the recent rise in postsecondary educational attainment is seen at the junior college level, where enrollment nearly doubled between 1990 and 1996 (Government of the Republic of Korea 1996).

South Korea has also expanded graduate S&E programs. In the 1980s, the Korean Advanced Institute of Science and Technology was established to increase support for postgraduate training within South Korea. More recently, Pohang University of Science and Technology was established by the industrial giant, Pohang Iron and Steel Corporation, much as institutions such as Stanford and Carnegie-Mellon were founded by early U.S. industrialists.

China. In the 1980s, the extensive infrastructure for graduate training in China was strengthened, after having been greatly disrupted during the late 1950s and the Cultural Revolution of the 1960s. China's policy of modernization through science and technology resulted in a massive investment in higher education institutions, particularly to increase enrollments in S&E at the undergraduate and graduate levels. The expansion and upgrading of such institutions were partially financed by a series of international loans from the World Bank; from 1981 to 1991, these loans totaled $1.2 billion. (See text table 2-2.)

China specifically requested international development assistance loans for higher education as part of its economic plan to bolster its high-technology manufacturing sectors. The loans improved research instrumentation and computing facilities, allowed both senior scholars and younger students to study abroad, and provided for several hundred international advisors to assess departments and advise on curricular reform (Hayhoe 1989).

Part of China's strategy was to improve the quality of teaching and research in higher education by sending selected students to study in foreign universities, especially in NS&E fields. At first, most students and research scholars were government supported and returned to China after their studies. Between 1979 and 1988, approximately 19,500 Chinese scholars and graduate students who had studied in the United States returned to China; they subsequently became an important component of China's science and technology resources (Orleans 1988). Currently, only a small fraction of Chinese foreign students are government supported, and return rates to China are low. (See "Stay Rates of Foreign Doctoral Recipients in the United States" later in this chapter.)

There are more than 1,000 higher education institutes in China. Seventy of them provide four-year university programs; 43 are comprehensive universities. In 1988, about 86 of China's higher education institutions were singled out as centers of excellence for priority funding (NSF 1993).

Text table 2-2.
Recent World Bank education projects in China
(Millions of current U.S. dollars)

Project topic	Total	Loan	Credit	Years
University development I	200	100	100	1981-86
Agricultural education/ research I	75		75	1982-88
Polytechnic/TV university	85		85	1983-89
Agricultural education II	69	45	24	1984-89
Rural health and medical education	85		85	1984-89
Agricultural research II	25		25	1984-89
University development II	145		145	1985-90
Provincial universities	120		120	1985-90
Technical education	130		130	1987-91

NOTE: Loans are funded by the World Bank's International Bank for Reconstruction and Develppment at commercial rates. Credit is provided by the World Bank's International Development Association; this funding is interest free and has lengthy repayment terms.

SOURCE: R. Hayhoe, *China's Universities and the Open Door* (Armonk, NY: M.E. Sharpe, Inc., 1989).

Science & Engineering Indicators – 1998

Growth in Institutions of Higher Education in Europe

In the 1960s, the accelerated pace of European economic development created a demand for more skilled labor, and the expansion of the middle class caused a great demand for higher education. Governments in Europe responded to these pressures by forming so-called "non-university" tertiary level institutions, such as the *Instituts Universitaires de Technologie* in France in 1966, polytechnics in the United Kingdom in 1969, and the *Fachhochschulen* in Germany in 1971 (Academia Europea 1992). The small number of students in secondary and higher education in these countries began to expand. Similar institutions arose throughout other Western European countries during this period, thus broadening the student base in higher education. The largest numbers of institutions are found in Germany, France, and the United Kingdom.

Germany. German higher education takes place at 251 institutions, among them 125 *Fachhochschulen* and 70 universities, including 6 private universities. Only university graduates may continue their studies through doctoral programs. The university degree in Germany requires a minimum of 4 years of study; the average length of undergraduate study is 6.5 years. This lengthy first university degree reflects both the quality of university education and the great overcrowding of universities, a phenomenon that occurs throughout Europe. University education is funded by the federal government and the *Lander* (states), and the numbers of institutions and faculty positions have not expanded in proportion to the increasing number of students (Von Friedeburg 1991). The German Government has established 26 new *Fachhochschulen* in the former East Germany to create a more highly skilled labor force and to foster economic growth in that region (Government of the Federal Republic of Germany 1994).

France. Institutions of higher education in France include universities; technical institutes; and *Grandes Écoles* of engineering, business, and administration. The vast majority of students are in universities; only 90,000 students attend the prestigious *Grandes Écoles* (Feldman and Morelle 1994). Postsecondary two-year technology programs grew rapidly in the 1980s at the University Institutes of Technology and the *Sections de Technicien Supérieur* (Charlot and Pottier 1992).

United Kingdom. Until recently, higher education institutions in England and Wales were divided into three sectors: universities, polytechnics, and colleges. Most provide three-year degrees (following a 13-year elementary and secondary program), although degree awards in NS&E fields usually take four years. The universities are the longest established of the three sectors. Colleges were founded in the late 19th century for training personnel for local employers. Thirty polytechnics were created in the 1960s to broaden access to higher education for groups traditionally underrepresented. They originally were to have a vocational focus, but the course offerings of the polytechnics have gradually become similar to those of universities. In 1992, most polytechnics attained university status. The 46 existing universities retained their role as prime providers of research and still account for the large majority of natural science degrees. Only about half of all engineering and computer science degrees are obtained in universities, however; the other half are obtained in polytechnics and specialized colleges (Tarsh 1992).

(For more information on institutions of higher education in Germany, France, and the United Kingdom, see NSF 1996a.)

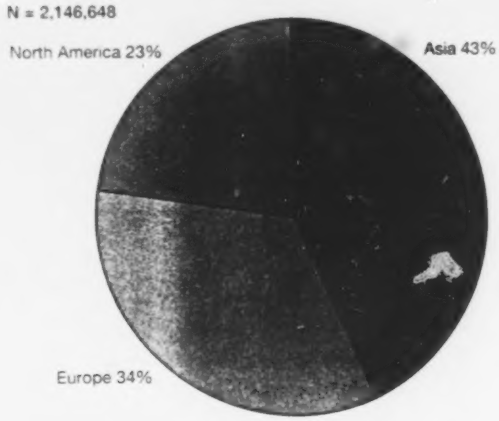
completions in S&E fields. In the United States, the ratio of NS&E degrees to total first university degrees has declined from 21 percent in 1987 to 15 percent in 1995. (See NSF 1993 and appendix table 2-6.) In contrast, Mexico has had an increasing college-age cohort and an expansion of earned university degrees from 1980 to 1992, particularly in engineering. Recent data from Mexico (1993 and 1994) show a decline in NS&E degrees, but this is due to major changes in taxonomies used in the classification of NS&E degrees and in the graduation requirements within Mexico's university system. (ANUIES 1996b.)

Regional Proportions of S&E Degree Production

Opportunities for S&E education are increasing throughout the world, consequently, the U.S. proportion of the total is decreasing. In 1995, earned degrees in S&E in the North American region represented 23 percent of the three-region total. (See figure 2-2.) The United States represented less than 18 percent of such earned degrees. In considering only NS&E fields (excluding the social sciences), the U.S. proportion is even smaller.

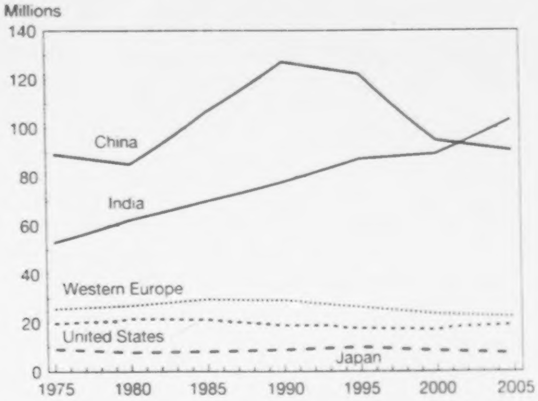
Even though the lack of time-series data for all countries in these regions prevents a statistically sound comparison of regional proportions from an earlier period, the higher rate of change in the distribution of S&E degrees over time in other world regions has implications for the United States and other countries. The global diffusion of S&E education also has implications for the U.S. higher education system. Other countries' increasing capacity to educate in advanced levels of S&E helps explain the decline in foreign student enrollment in engineering programs in the United States. (See "Bachelor's Degrees in S&E" and "Trends in Graduate Enrollment" later in this chapter.) In addition, the continuing expansion of global capacity for S&E education has implications for all nations, since it indicates an increased potential for technological and economic development worldwide.

Figure 2-2.
First university degrees in S&E in three world regions: 1995 or most recent year



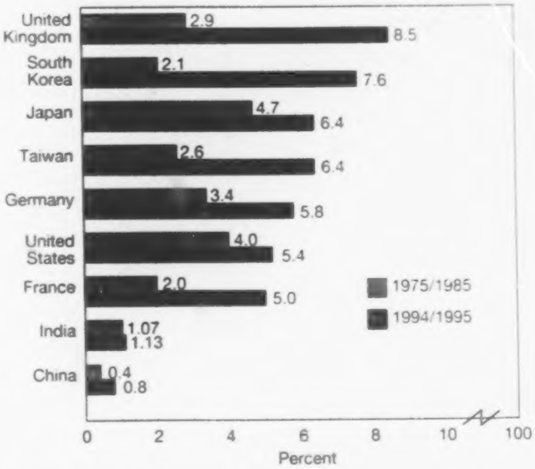
See appendix table 2-1. *Science & Engineering Indicators – 1998*

Figure 2-3.
Trends in population aged 20-24: 1975-2005



See appendix table 2-3. *Science & Engineering Indicators – 1998*

Figure 2-4.
Proportion of 24-year-olds earning NS&E degrees, by country



NOTES: European data are for 1975 and 1994; Chinese data are for 1985 and 1995. Other countries' data are for 1975 and 1995. NS&E is natural sciences and engineering.

SOURCES: National Science Foundation, Science Resources Studies Division (NSF/SRS), *Human Resources for Science and Technology: The Asian Region*, NSF 93-303 (Washington, DC: 1993); and NSF/SRS *Human Resources for Science and Technology: The European Region*, NSF 96-319 (Arlington, VA: 1996); and appendix table 2-1.

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Reasons for the Global Increase in S&E Education

Demographics

The increase in S&E degree production in Asia is driven by the expansion of access to higher education for large or growing populations. Developing countries such as India and China have large populations in their college-age cohort and increasing participation rates in postsecondary education, while the industrialized countries of Japan, Western Europe, Canada, and the United States have declining student populations. Trend data on China's 20- to 24-year-old population show a decline from 1990 to 2005, but the number in this age segment is over 100 million for 1998. India's college-age cohort will have increased to 88 million by 1998. In contrast, the college-age population in Western European countries as a whole has declined from 30 million in 1985 to 25 million in 1998, and will continue to decline until 2005. The U.S. college-age cohort has been decreasing since 1980, and will continue to do so until 2000, when this age segment will slowly begin to rise. Japan's college-age population (10 million in 1995) will decrease by 30 percent in the next 15 years. (See figure 2-3 and appendix table 2-3.)

Increasing Participation Rates in NS&E Degrees

Taiwan and South Korea dramatically increased their production of NS&E degrees from about 2 percent of their 24-year-olds in 1975 to 6 and 7 percent, respectively, in 1995. (See figure 2-4.) Japan has consistently had a high percentage of its 24-year-olds completing NS&E degrees since the 1970s: a slight decline in NS&E recipients in the late 1980s was followed by yet more growth in the 1990s. (See appendix table 2-1 for 1995 data and NSF 1993 for trend data on Asian countries.)

Asia's two population giants, India and China, have low attainment rates of NS&E degrees. India, with its huge, growing population, is maintaining its participation rate of 1.1 percent. In 1985, just under 0.9 percent of China's college-age population earned a bachelor's degree, and approximately 0.5 percent earned a degree in an NS&E field. Within a decade, these percentages rose to 1.3 percent with a bachelor's degree and 0.8

percent with an NS&E degree, although participation rates are still far lower than those for developed countries. (See appendix table 2-1; see NSF 1993 for trend data on Asian countries.) If China continues to increase its participation rate in NS&E degrees, and India can maintain its current rate with a growing population, the world stock of science and engineering graduates will be greatly augmented, and the U.S. share of S&E degrees will be reduced.

A declining pool of college-age students in Europe has not resulted in declining numbers of NS&E degrees, as has occurred in the United States. Rather, participation rates in higher education and NS&E degrees, previously low, have grown to more than offset the declining population. In Finland, for example, 9 percent of the college-age cohort obtains a university degree in the natural sciences or engineering—one of the highest participation rates in the world.

Differences in Participation Rates by Sex

The growth in participation rates in NS&E degrees differs considerably for males and females across countries. Japan shows the largest disparity in completion of NS&E degrees by males and females of college age. In 1995, more than 11 percent of males in the college-age population earned an NS&E degree. One percent of Japan's females earned such a degree. South Korea has a similarly high percentage of college-age males earning an NS&E degree, and 4 percent of its female college-age population earned such a degree. In the United States, 7 percent of college-age males earned an NS&E degree, as did almost 4 percent of females. (See appendix table 2-4.)

In countries of the three world regions examined, women have been particularly successful in earning degrees in the natural sciences and the social sciences. By 1995, women earned 50 percent of the natural science degrees in higher education institutions in the United Kingdom, 54 percent in Italy, 47 percent in the United States, and 44 percent in South Korea. In most countries in the three regions, women have also earned the majority of first university degrees in the social sciences. The notable exceptions are Japan and South Korea, where women earn only a modest proportion of social science degrees—19 and 27 percent, respectively. Women in all countries are considerably less likely to earn degrees in engineering. (See appendix table 2-5.)

Focus on S&E in Higher Education

Part of the reason for this rapid Asian growth has been the greater focus on these fields within Asian universities, with high quotas set for enrollments in these departments. Reflecting China's strategy to develop its economy through science and technology (see "Growth in Institutions of Higher Education in Asia"), 72 percent of its first university degrees are earned in S&E fields. In addition, about 67 percent of Japanese degrees and 46 percent of South Korean were in these fields. Among European countries, 46 percent of first university degrees in Germany and Finland are in S&E. Russia and Central and Eastern European countries are similarly focused on science and engineering. In contrast, less than one-third of first university degrees (bachelor's degrees) in the United States are earned in S&E. (See appendix table 2-6.)

Characteristics of U.S. Higher Education Institutions

The United States has a large and diversified set of institutions of higher education that provides a college or university education to over one-third of the U.S. college-age population. (See appendix table 2-1.) This access to higher education ranks the United States among those countries with the most open education systems in the world.

In the United States, there were 3,681 (1,594 public and 2,087 private) institutions of higher education in 1995 (HEP 1997). These institutions enrolled 14.4 million students at all degree levels (associate, bachelor's, master's, and doctoral) in that year and awarded 2.2 million degrees, almost one-quarter of which were in S&E. (See figure 2-5.) The Carnegie Foundation for the Advancement of Teaching has classified these institutions into 10 categories based on the size of their baccalaureate and graduate degree programs, the amount of research funding they receive, and—for baccalaureate colleges—their selectivity.[7] Following is a brief description of these categories.

- ***Research universities I.*** These institutions offer a full range of baccalaureate programs, are committed to graduate education through the doctorate, and give high priority to research. They award 50 or more doctoral degrees each year, and receive $40 million or more annually in federal support.

- ***Research universities II.*** These institutions are the same as research I, except that they receive between $15.5 million and $40 million annually in federal support.

- ***Doctorate-granting I.*** In addition to offering a full range of baccalaureate programs, the mission of these institutions includes a commitment to graduate education through the doctoral degree. They award 40 or more doctoral degrees annually in at least five academic disciplines.

- ***Doctorate-granting II.*** These institutions are the same as doctorate-granting I, except that they award 20 or more doctoral degrees annually in at least one discipline or 10 or more doctoral degrees in three disciplines.

- ***Master's (comprehensive) universities and colleges I.*** These institutions offer baccalaureate programs and, with few exceptions, graduate education through the master's degree. More than half of their baccalaureate degrees are awarded in two or more occupational or professional disciplines, such as engineering or business administration.

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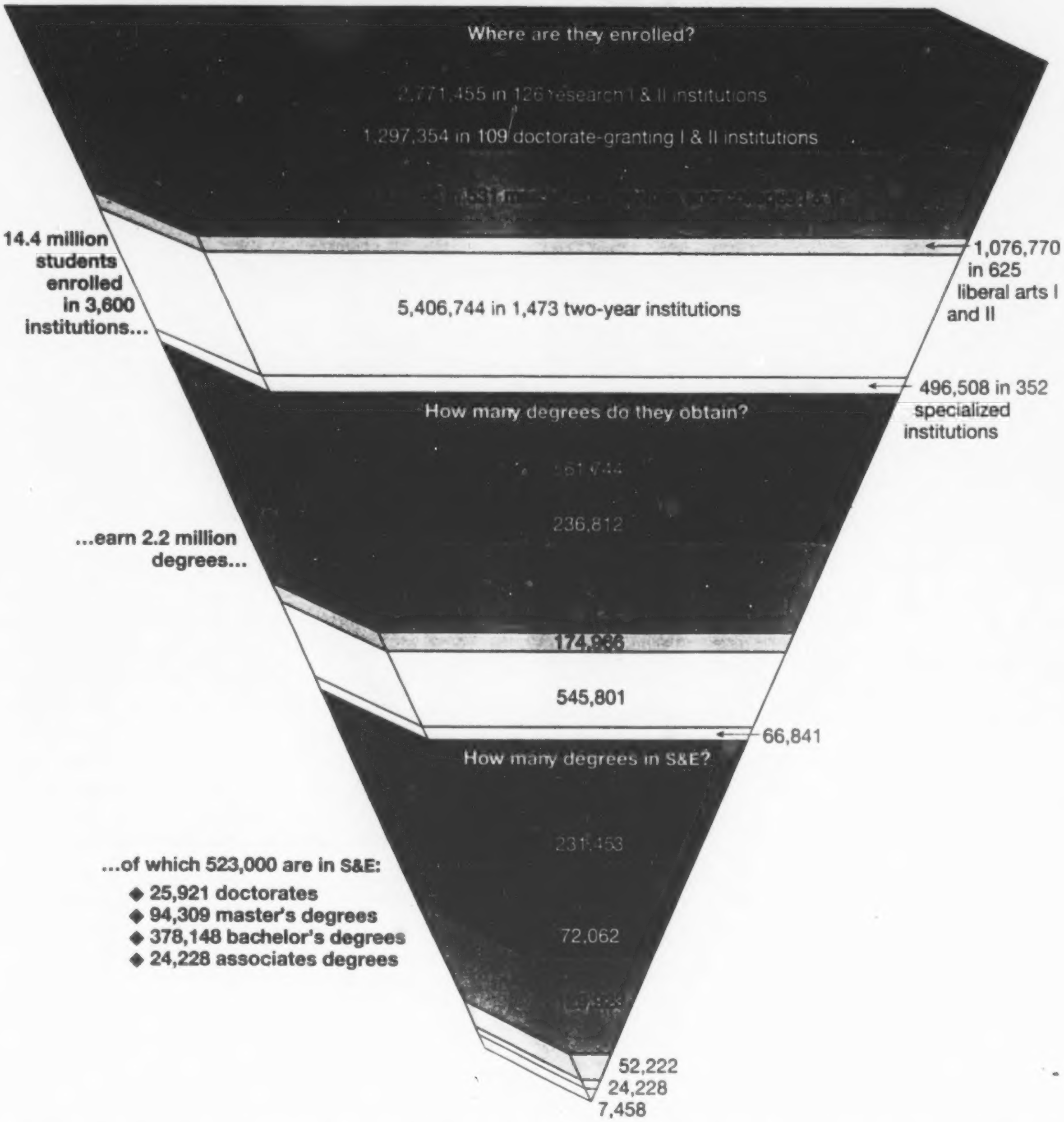
[7] The Carnegie classification is not an assessment guide, nor are the distinctions between classification sublevels (e.g., research I and research II) based on institutions' educational quality. Baccalaureate college I institutions exercise more selectivity regarding students than do baccalaureate colleges II, but in general the Carnegie categories are a typology, not a rank ordering.

Figure 2-5.
U.S. higher education in 1995: Students, institutions, and degrees



14.4 million students enrolled in 3,600 institutions...

...earn 2.2 million degrees...

...of which 523,000 are in S&E:

- ◆ **25,921 doctorates**
- ◆ **94,309 master's degrees**
- ◆ **378,148 bachelor's degrees**
- ◆ **24,228 associates degrees**

NOTE: This figure represents relative sizes of enrollments and degrees within Carnegie categories of institutions in 1993. It does not depict the dynamics of higher education or the movement of students among institution types prior to graduation.

See appendix tables 2-8, 2-9, 2-10, and 2-18.

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The U.S. Higher Education System

The U.S. system of higher education is characterized at the undergraduate level by diverse institutions that provide flexible access to higher education for a broad range of U.S. citizens. At the graduate level, the system serves not only U.S. students but international students as well. Demographic changes (for example, a pending upturn in the population of college-age students, with higher percentages of minorities underrepresented in S&E), the increasing capabilities of other nations, and job-seeking experiences of recent graduates are prompting a reexamination of the U.S. system of higher education.

At the undergraduate level, the U.S. system provides access for a broad cross-section of citizens. About one-third of the college-age cohort completes a college or university education in some field. Although some European countries are approaching this high level of access, the European region as a whole reaches only about half that proportion of its college-age cohort. Contributing to this broader U.S. access is the expansive institutional base of U.S. higher education, which allows for flexibility in transferring among institutions and diverse attendance patterns. Over one-third of the 15 million students in U.S. higher education are in community colleges. These institutions let students transfer credits to four-year colleges and universities; they also provide considerable remedial coursework for students who were not well-served by, or well-motivated during, their high school education. (Chapter 1 discusses this phenomenon, with particular reference to middle and high school teachers teaching out of their field, especially in math and science.)

This expansive institutional base, however, is also characterized by uneven quality and highly differential resources. Many minority students are in community colleges; although this can facilitate their continuation in the higher education system, this level of the system is the most poorly funded and has the worst track record for graduation. Only a small percentage of minority students or students from poor families completes an associate degree in an S&E field and subsequently enters a four-year institution. Moreover, since most mathematics courses at the community college level are remedial, they are not transferable to four-year institutions. This route in the U.S. higher education system has not yet resulted in commensurate representation of minority groups in earned degrees in science, mathematics, and engineering. (See "S&E Human Capital Development: Continued Unevenness Across Demographic Groups" later in this chapter.)

With its blend of advanced coursework and research experience, U.S. graduate education in S&E is considered to be among the best in the world. In the last 10 years, U.S. graduate programs have expanded, particularly at the doctoral level. Academic R&D has also grown during this period, and an increasing number of foreign students have enrolled in U.S. graduate S&E programs. Between 1985 and 1995, the number of doctoral degrees awarded in engineering, mathematics, and the computer sciences doubled. Much of this growth was due to foreign doctoral recipients, many of whom earned their S&E degrees while supported as research assistants. Postdoctoral positions increased at almost the same rate, and foreign students earned an increasing proportion of these appointments—slightly more than half by the 1990s. (See chapter 5, "Integration of Research With Graduate Education.") Beginning in 1993, however, foreign student enrollment in U.S. graduate S&E programs experienced a decline, which, if it continues, will reduce the proportion of S&E degrees and postdoctoral appointments awarded to foreign students.

Decisionmakers throughout the U.S. higher education system are examining both undergraduate and graduate levels to broaden participation of all groups in science and engineering, and to broaden career choices for those with advanced degrees. At the undergraduate level, a revitalization of science and mathematics curricula is aimed at better teaching of all students, enhanced teacher preparation for K-12 programs, and greater retention of students in S&E departments. Educators are forming partnerships between the faculties of two- and four-year schools to improve academic courses at community colleges and establish agreements for transferring credits. In graduate education, the appropriateness of current training for careers in industry as well as in academia is being examined.

Reforms in U.S. higher education are particularly important in light of ongoing demographic changes. A two-decade-long decline in the college-age cohort in the United States reduced the traditional college-age population from 22 million in 1980 to 17 million in 1995. This declining trend is expected to reverse itself in the year 2001. The projected increasing student population will then create a demand for yet further expansion of the U.S. higher education system.

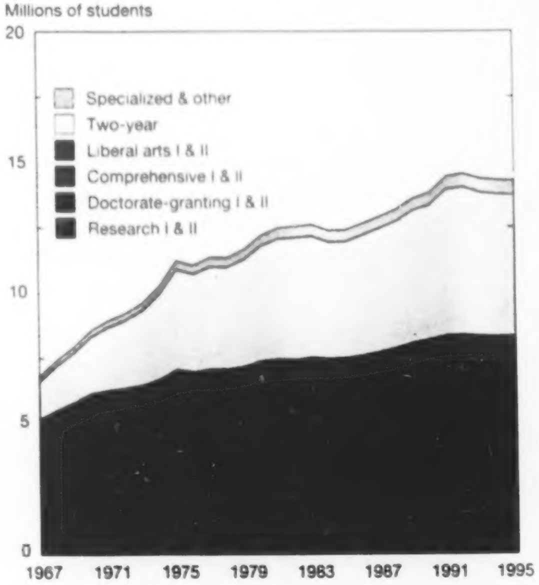
All of the institutions in this group enroll at least 2,500 students.

- ◆ ***Master's (comprehensive) universities and colleges II.*** These institutions are the same as master's universities and colleges I, except that all of the institutions in this group enroll between 1,500 and 2,500 students.
- ◆ ***Baccalaureate (liberal arts) colleges I.*** These highly selective institutions are primarily undergraduate colleges and award more than 40 percent of their baccalaureate degrees in liberal arts and science fields.
- ◆ ***Baccalaureate (liberal arts) colleges II.*** These institutions are primarily undergraduate colleges that award less than 40 percent of their degrees in liberal arts and science fields. They are less restrictive in admissions than baccalaureate colleges I.
- ◆ ***Associate of arts (two-year) colleges.*** These institutions offer certificate or degree programs through the associate degree level and, with few exceptions, offer no baccalaureate degrees.
- ◆ ***Professional schools and other specialized institutions.*** These institutions offer degrees ranging from the bachelor's to the doctorate. At least half of the degrees awarded by these institutions are in a single specialized field. These institutions include theological seminaries, bible colleges, and other institutions offering degrees in religion; medical schools and centers; other separate health profession schools; law schools; engineering and technology schools; business and management schools; schools of art, music, and design; teachers' colleges; and corporate-sponsored institutions.

After several decades of continual and rapid expansion of higher education in the United States, enrollment fell for the first time in 1993; it has continued to decline each year since then. (See figure 2-6 and appendix table 2-8.) This decline is partially based on demographics: the U.S. college-age population declined from 22 million in 1980 to 17 million in 1995. (See appendix table 2-3.) However, the decline in the college-age population was offset for over a decade by expanded access to higher education for all subpopulations, particularly women and minorities, and enrollment by larger numbers of older students. The U.S. college-age cohort will again increase beginning in 2001, and higher education enrollments are expected to increase concurrently.

A diverse spectrum of institutions contributes to the S&E degrees in the United States. The country's 126 research universities provide the majority of engineering degrees and a large proportion of natural and social science degrees at both the graduate and undergraduate levels. (See figure 2-7.) In 1995, research universities enrolled only 19 percent of all students in higher education, but produced over 46 percent of all S&E degrees. (See appendix tables 2-8 and 2-9.) In contrast, the associate of arts colleges enroll a large proportion of all students in higher education, but account for only a small percentage of S&E degrees. In 1995, only about 10 percent of the over 5.4 million students attending junior colleges completed an associate degree—less than 1 percent in an S&E field. These two-year colleges, however, provide continuing education and flexibility in the U.S. higher education system, allowing students to complete needed work-related courses or to obtain credits for transfer to a four-year college or university. (See "The U.S. Higher Education System.")

Figure 2-6.
U.S. enrollment in higher education, by institution type



See appendix table 2-8. *Science & Engineering Indicators – 1998*

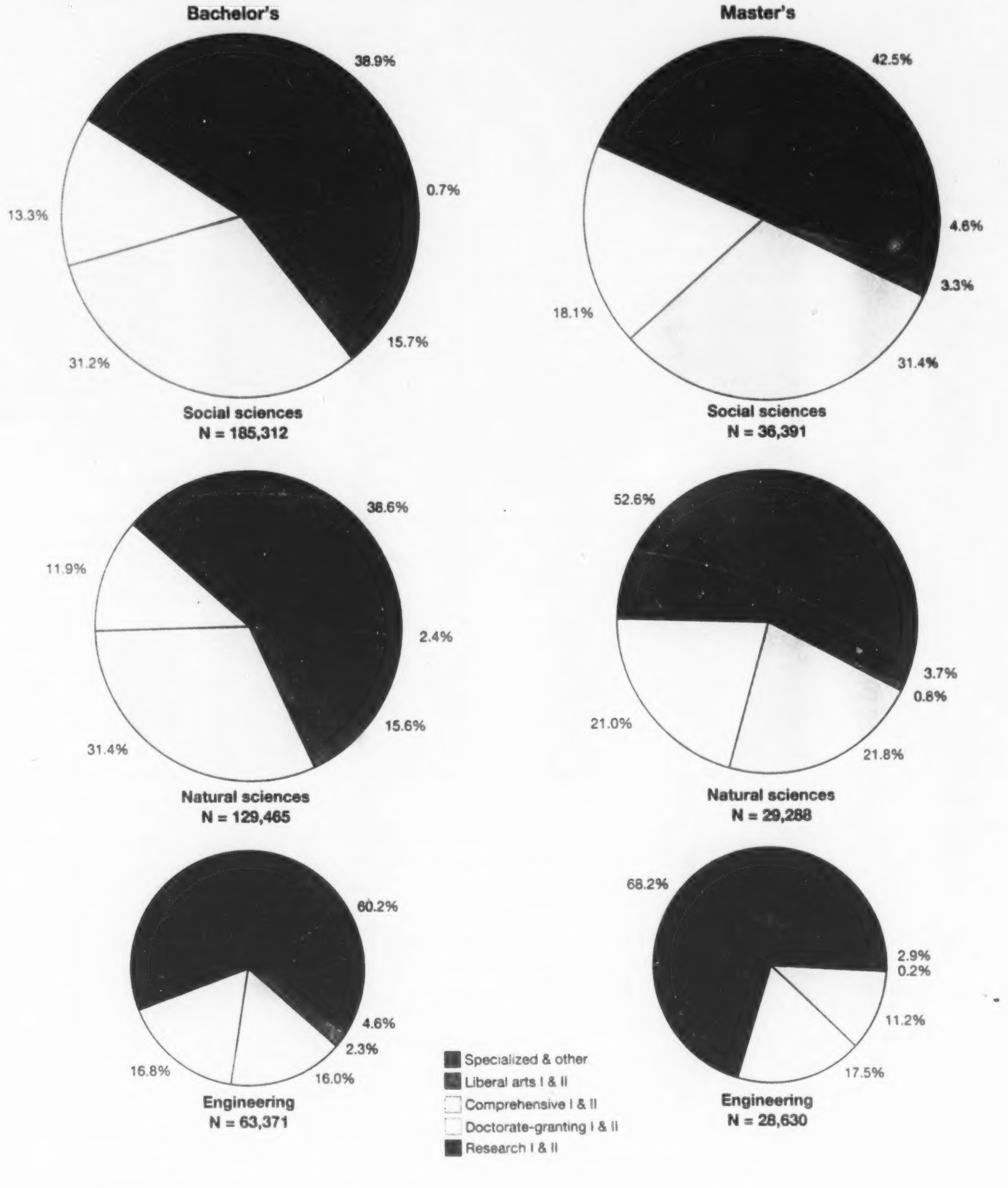
Undergraduate S&E Students and Degrees in the United States

Recent Trends in College Enrollment

For almost a decade starting in 1984, undergraduate enrollment in U.S. institutions of higher education showed strong growth, peaking in 1992 with nearly 12.7 million students. Undergraduate enrollment has declined slightly each year since, mainly from the decrease in the college-age cohort of the majority (white) population. The continuing increase in enrollment for all minority groups did not make up for the loss of white enrollment, resulting in an overall decrease.

The trend of increasing enrollment in undergraduate programs by underrepresented minorities has persisted for over a decade and accelerated in the 1990s. Black enrollment increased 3.6 percent annually in the 1990s, reaching 1.3 million in 1995. In the same period, Hispanic enrollment in higher education increased at an even faster rate (7.1 percent annually.) These

Figure 2-7.
Bachelor's and master's degrees awarded in S&E, by institution type: 1995



NOTE: Natural sciences here include mathematics and computer sciences.
See appendix table 2-9.

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national trend data bear watching as some states change affirmative action programs. Undergraduate enrollment of foreign students grew very modestly in the past two decades; in 1995, foreign students still represented only 2 percent of total undergraduate enrollment. (See appendix table 2-11.)

Characteristics of American College Freshmen Planning to Major in S&E

Need for Remedial Work in Mathematics and Science

One indicator of the readiness of American students for college-level S&E courses is their self-reported need for remedial work in mathematics and science. The percentage of freshmen reporting a need for such remedial work has remained high, particularly for women and minorities. In 1995, of those freshmen planning to major in science or engineering, over 16 percent of the males and over 26 percent of the females thought they would need remedial work in math. Among freshman students from underrepresented minority groups planning to major in S&E, over 38 percent reported that they would need remedial work in math. This self-reporting of the need for remedial work differed by planned major. Fewer of the students planning a major in the physical sciences or engineering reported needing remedial math, as compared to those planning a major in the social or biological sciences. (See figure 2-8.) Over 20 percent of minority students planning a major in the biological sciences or engineering thought they would need remedial work in science.

Freshmen Intentions to Major in S&E

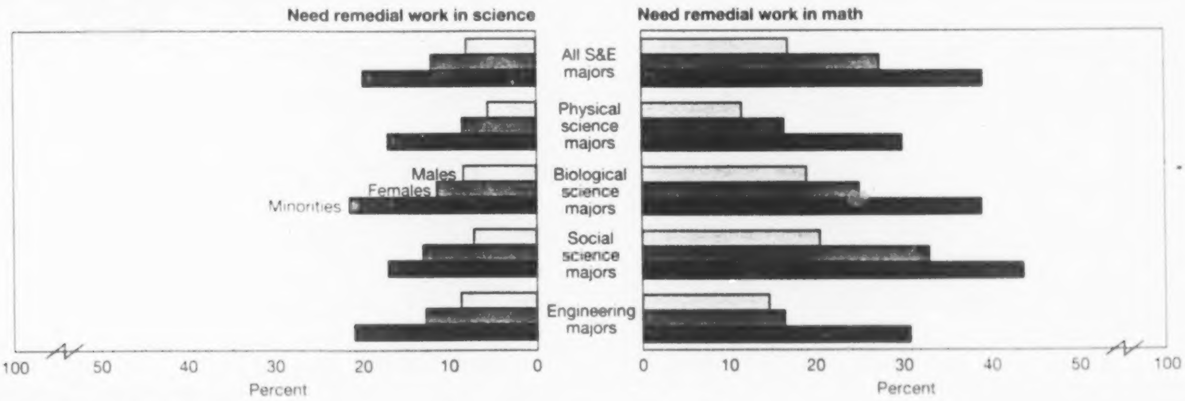
Among the majority (white) population, about one-third of the freshman have traditionally contemplated a major in an S&E field; most of these intend to major in a field of natural or social science, with smaller percentages selecting mathematics, the computer sciences, or engineering. From the late 1970s on, the percentage of freshmen planning an engineering major has remained relatively constant, at around 9 percent. During the same period, mathematics and computer sciences have been the intended majors of around 2 percent of incoming freshmen. Freshmen have fluctuated more in their choice of natural science and social science majors. After a decade-long decline in the selection of natural sciences as a possible major, the trend reversed in 1987, increasing to around 12 percent by 1996. The social sciences have become more attractive majors, but not as popular as the natural sciences. (See appendix table 2-15.)

Planned Majors and Completion Rates by Sex and Race/Ethnicity

Trends in freshman choice of major show differences by sex and race/ethnicity. Asian American students are moving away from a very high concentration of S&E majors—particularly in engineering—and are majoring in a broader range of fields. While still relatively high, the proportion of Asian American males choosing engineering as freshmen declined from 38 percent in 1980 to 23 percent in 1996. For many years, higher proportions of black and Hispanic males have chosen engineering than have white males, and a higher proportion of black females than white females have chosen to major in mathematics and computer sciences. Women of every race/ethnicity, however, show an increase in choice of natural sciences. (See appendix table 2-15.)

An increasing proportion of those students planning to major in S&E fields are from underrepresented minority groups. In 1996, underrepresented minorities accounted for 15 to 21 percent of those planning to major in the following fields: physical sciences, biological sciences, social sciences, and

Figure 2-8.
Freshmen reporting need for remedial work in science or math, by intended major: 1995

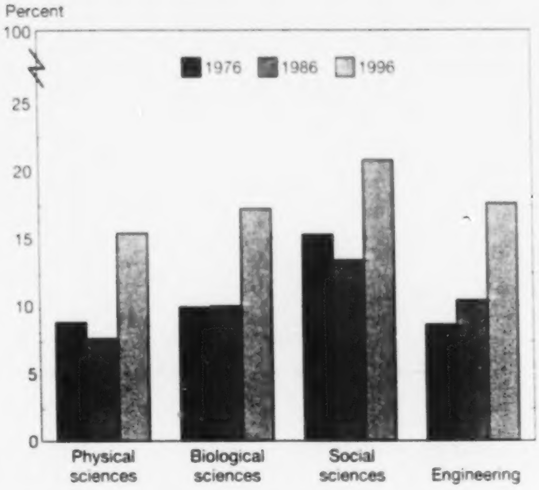


NOTE: As used here, minorities are those underrepresented in S&E: blacks, Hispanics, and Native Americans.

See appendix table 2-17.

Science & Engineering Indicators – 1998

Figure 2-9.
Minority representation among freshmen planning to major in an S&E field



NOTE: As used here, minorities are those underrepresented in S&E: blacks, Hispanics, and Native Americans.

See appendix table 2-16. *Science & Engineering Indicators – 1998*

engineering. In 1976, underrepresented minorities accounted for between 9 and 15 percent of those planning to major in these fields. (See figure 2-9.)

A substantial fall-off occurs between freshmen declaration of intent to study S&E fields and actual completion of S&E degrees (Astin and Astin 1992).[8] This fall-off differs by race, particularly in NS&E fields. There is some fall-off among the majority (white) students: 12 percent intend to major in natural sciences and 9 percent in engineering, but only 8 percent of degrees earned by white students are in the natural sciences and only 5 percent in engineering. A larger fall-off occurs among underrepresented minority groups. Ten percent of black students intend to study a field of natural science, but only 5 percent of degrees earned by blacks are in these fields. Further, 9 percent of black students intend an engineering major, but only 3 percent of undergraduate degrees earned by black students are in engineering. (See appendix tables 2-15 and 2-21.)

Engineering Enrollment

Engineering programs require students to declare their major as freshmen, allowing engineering enrollment to be used as an early indicator of undergraduate degrees. The composition of enrollment can also be used as an indicator of participation rates of women and minorities. Undergraduate engineering enrollment declined from a high of 441,205 students in 1983 to 356,177 students in 1996, representing a 19 percent reduction. The decline was neither smooth nor continuous. Engineering enrollment stabilized for several years (1989 to 1992) before resuming its decline. Part-time student enrollment, which accounts for about 10 percent of overall enrollment, has remained relatively stable during the last decade. The relative steadiness of engineering enrollment in the early 1990s is reflected in the stable number of engineering degrees in the 1993-95 period. (See appendix tables 2-13 and 2-20). However, the decline in overall engineering enrollment from 1993 portends a decline in engineering degrees at the end of the decade and in the year 2000.

While overall undergraduate engineering enrollment has been declining, enrollment of women and minorities has been increasing, particularly in the 1990s. The number of female students enrolled in engineering increased from 61,000 in 1990 to 68,000 in 1996. For underrepresented minorities, the increase was greater, from 41,000 in 1990 to almost 54,000 in 1996. By 1996, female students represented 19 percent of total undergraduate engineering enrollment, and underrepresented minorities represented 15 percent of such enrollment. Concurrently, the number of foreign students enrolled in U.S. undergraduate engineering programs has been decreasing, in response to enhanced capacity in engineering programs abroad. (See figure 2-10 and appendix table 2-14.)

Science and Mathematics Coursetaking

Universities strive to address the academic needs of students in all majors. In addition to S&E, disciplines that require a grounding in mathematics and science include K-12 education, business, and law, among others. With the increasing interplay of science and technology in our society, all citizens benefit from a higher level of technological literacy and an understanding of the methods and processes of science.

Curricular Reform

In the 1990s, many S&E departments have designed or adapted new curricula to broaden the attraction to, and success with, science and engineering courses. For example, several academic institutions have initiated "calculus reform," a movement to align calculus instruction more closely with theories of how students learn; others have created multimedia software modules to enhance visualization for students not majoring in science. A large number of institutions have adopted or designed revitalized curricula or variations of these reforms. (Advisory Committee to NSF EHR 1996). By 1995, 22 percent of the 372,000 students enrolled in calculus 1 and 2 were using a reform text[9] along with various other innovations, such as graphing calculators, writing and computer assignments, and group projects (Rung 1997).

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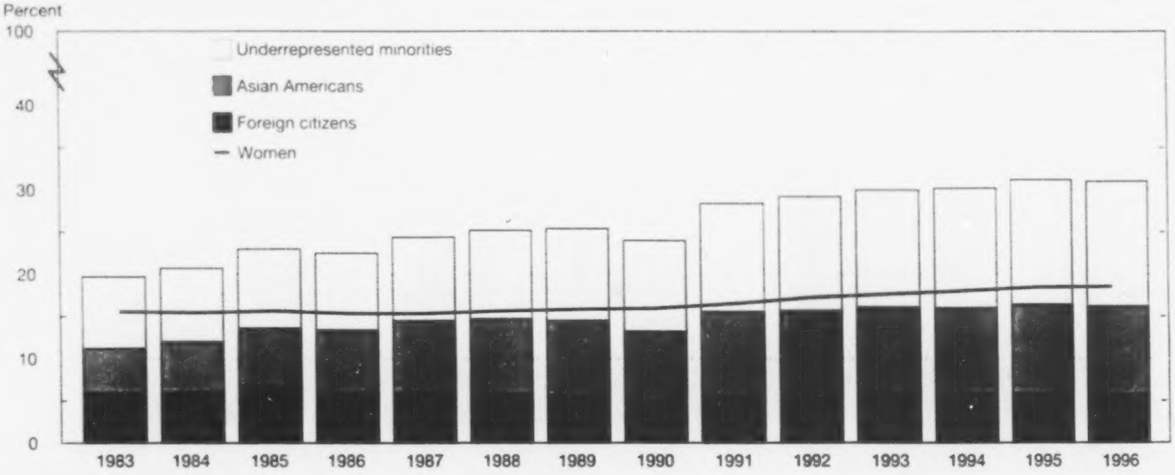
[8] Freshman intention data are estimates based on a sample of surveyed students, while degree data are the universe of earned degrees. Therefore, the fall-off in percentages for intentions and actual degrees cannot be measured precisely. Further, the data are not limited to freshmen who actually go on to earn degrees. The comparison does, however, show that there is a fall-off, and that the magnitude is greater for minority students.

[9] A text reflecting the pedagogical principles of the reform calculus movement.

Figure 2-10.
Representation of women and minorities in undergraduate engineering enrollments



NOTE: Minorities underrepresented in S&E are blacks, Hispanics, and Native Americans.
See appendix table 2-14.

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Number of Courses Taken in Science and Mathematics

Recent data from the Longitudinal Study of American Youth (LSAY) reveal some facts about coursetaking behavior in science and mathematics among those who attended two- or four-year colleges and universities. As expected, science, engineering, and mathematics majors report a far higher number of completed mathematics and science courses than non-S&E majors. Over half of the mathematics and engineering majors report five or more courses in mathematics. Over 90 percent of the science majors report five or more courses in science. However, many non-S&E majors are taking mathematics and science courses beyond the general education requirements (in a liberal arts program, typically two mathematics courses and two science courses to graduate). Over half of the education majors who earned a bachelor's degree took three to four mathematics courses, with over 40 percent taking three to four courses in science and 25 percent taking even more. (See appendix tables 2-22 and 2-23.)

Level of Mathematics Courses in Undergraduate Education

Every five years since 1970, the Conference Board of the Mathematical Sciences (CBMS) has conducted a survey of a sample of four-year college and university departments of mathematics and two-year college programs in mathematics. These data are important in estimating overall enrollment trends, as well as in breaking out trends in mathematics courses taken by level of difficulty. Estimates of overall enrollment in courses taken in mathematics departments in four-year institutions declined substantially from the peak years of 1985 and 1990, as fewer undergraduate students majored in mathematics or took calculus or advanced level coursework.

The CBMS data show that mathematical enrollment trends differed by level of institution as well as level of difficulty. Enrollment increased in precalculus courses designed primarily for liberal arts students in four-year colleges and universities, and in remedial mathematics courses in two-year colleges. In 1995, at the community college level, over half (57.8 percent) of the enrollment in mathematics classes was for remedial level courses. This high proportion of remedial mathematics at the community college level has existed since 1985. In 1970, remedial courses in community colleges represented about one-third of all mathematics courses. Within four-year college and university mathematics departments, the estimated enrollment in remedial level courses has remained at about 15 percent of total mathematics enrollment since 1980. The proportion of mathematics enrollment in advanced courses has remained within a range of 6 to 9 percent since 1980, with enrollment in precalculus and calculus each accounting for about 40 percent of total mathematics enrollment). (See text table 2-3.)

Associate Degrees in S&E

At the associate degree level, the number of degrees in engineering technology has fallen precipitously, from 51,000 earned degrees in 1983 to 39,000 degrees in 1995. (See appendix table 2-18.) Between 1994 and 1995, the number of degrees decreased in all fields of S&E. This decline in associate degrees in S&E holds regardless of race/ethnicity. (See appendix table 2-19.) The one exception is Asian American students: in the sciences, their number of earned degrees is increasing slightly.

Text table 2-3.
Estimated enrollment in undergraduate mathematics courses
(Thousands)

	Fall enrollments in math departments of four-year institutions					Fall enrollments in math programs of two-year institutions				
Course level	1970	1980	1985	1990	1995	1970	1980	1985	1990	1995
All math courses	1,188	1,525	1,619	1,619	1,469	555	925	900	1,241	1,384
Remedial	101	242	251	261	222	191	441	482	724	800
Precalculus	538	602	593	592	613	134	180	188	245	295
Calculus	414	590	637	647	538	59	86	97	128	129
Advanced	135	91	138	119	96	0	0	0	0	0
Other						171	218	133	144	160

NOTE: Precalculus-level mathematics courses include algebra and trigonometry courses, as well as courses for nonscience majors, finite mathematics, non-calculus-based business mathematics, and mathematics for prospective elementary school teachers.

SOURCE: D.C. Rung, "A Survey of Four-Year and University Mathematics in Fall 1995: A Hiatus in Both Enrollment and Faculty Increases," *Notices of the AMS,* Vol. 44, No. 8 (September 1997): 923-31.

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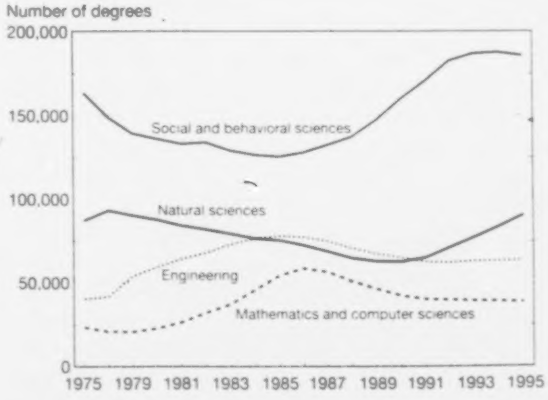
The declining trend in associate degree completions may be partly explained by the changing roles of junior colleges in the United States. Community colleges now go far beyond providing associate of arts degrees. They provide short courses, train in work-related technical skills, and serve as feeder schools to four-year colleges and universities. In contrast to the junior college level in many other countries— such as Japan and France—this level of higher education in the United States provides flexibility, allowing individuals to take courses outside of a degree program, as well as transition to more advanced levels of higher education. Many associate of arts colleges have an agreement with four-year schools to allow transfer of credits. For example, California encourages students to begin their college studies at a local community college, with the understanding that they will be admitted to a state university for their third and fourth years of a bachelor's degree.

Community colleges also pioneered distance learning to reach large numbers of students within their geographic region, and are partnering with universities to provide distance learning with local laboratory work. (See "Distance Learning and Its Impact on S&E Education.")

Bachelor's Degrees in S&E

Except for a brief decline between 1986 and 1989, the number of earned bachelor's degrees in S&E from U.S. institutions has been increasing for over a decade, rising from over 307,000 in 1981 to 378,000 in 1995. Trends in earned S&E degrees in U.S. institutions, however, differ widely by field. In the natural sciences, a long slow decline from 1976 to 1990 ended, shifting to an upturn in such degrees during the 1990s. Natural science degrees increased 7.7 percent annually from 1990 to 1995, with stronger than average growth in the biological and environmental sciences, but only modest (2 percent) growth in the physical sciences. The number of completed math and computer science degrees declined from 1975 to 1979, then climbed steadily reaching almost 59,000 degrees in the peak year of 1986. Attraction to the computer sciences dropped precipitously from 1986 to 1991, followed by slight decreases to 1995. The number of social science degrees awarded, after record growth between 1986 and 1992 (averaging 6 percent annually), has remained stable for the last four years. Engineering degrees, whose numbers also peaked in 1986 following a decade of strong growth—particularly in electrical and mechanical engineering—declined until 1991 and then stabilized. The slight annual growth rate in engineering degrees from 1991 to 1995 is mainly accounted for by the increasing number of degrees in chemical and civil engineering. (See figure 2-11 and appendix table 2-20.)

Figure 2-11.
Bachelor's degrees awarded in S&E



See appendix table 2-20. *Science & Engineering Indicators – 1998*

Distance Learning and Its Impact on S&E Education

Virtually all of the 300 engineering programs in the United States have some form of continuing education with distance learning for a local area; less prevalent but growing is generalized distance learning, with course material on the Internet. Students are increasingly participating in fully developed S&E lessons at home, at the office, in a library carrel, or even at another university. The impetus for distance learning stemmed from the responsibility of community colleges to serve a large number of students within a geographic region, and their need to develop off-site learning centers. In a 1991 survey by the American Association of Community and Junior Colleges, 80 percent of community colleges and 78 percent of universities had plans to provide distance learning by 1994 (Brey 1991).

S&E higher education has benefited from advances in distance learning. In the 1980s, television became an instrumental medium for developing courses and degree programs at the undergraduate and graduate levels. One example is the University of California at Davis Instructional Television program. Classes are broadcast live during the workday, and students usually enroll in one course per quarter. Full-time professional engineers obtain a master's degree in approximately three years and a doctoral degree within five to six years.

Telecommunications and satellite delivery make it possible for students to obtain their degrees almost anywhere in the world. Colleges and universities are using these support technologies to augment their existing distance learning programs—e.g., fax, CD-ROM, e-mail, two-way audio, and teleconferencing. (See text table 2-4.) For example, the National Technological University, a consortium of 47 leading engineering universities, offers 1,200 courses and 13 master's degree programs in science and engineering.

The Internet offers a fundamental advancement in distance learning delivery. The new Internet applications for audio, video, and two-way communication are expected to integrate the previous advancements in distance learning technologies into a single medium. Schools are beginning to experiment with on-line courses; for example, the University of Phoenix offers on-line courses that present workshops, homework, and even the final exam via the Internet. The Internet's impact on S&E higher education is not clear at this time, but several S&E associations are actively discussing its potential. (For more information, see chapter 8, "IT, Education, and Knowledge Creation.")

Text table 2-4.
Percentage of academic institutions using various technologies in distance learning programs

	Four-year universities		Two-year colleges	
Technology	1991	1994	1991	1994
Audio teleconferencing	30.0	37.0	12.0	25.0
Audiographics	10.0	22.0	5.0	14.0
Cable television	22.0	45.0	14.0	35.0
Compressed video/phone	13.0	35.0	3.0	16.0
ITFS	29.0	46.0	16.0	34.0
Microwave	25.0	37.0	12.0	27.0
Satellite (full motion)	33.0	52.0	15.0	30.0
Satellite (VSAT)	1.0	18.0	0.5	8.0

NOTES: Audio teleconferencing refers to telephone lines used to create interactivity among several sites. Audiographics is audio teleconferencing in conjunction with computer technologies to include graphics and still images. Compressed video/phone is compressed video via telephone lines. ITFS is instructional television fixed service (broadcast). Satellite (full motion) is full motion analog video transmission. Satellite (VSAT) is very small aperture terminals, interactive digital video network. 1994 data represent projected usage.

SOURCE: Ron Brey, "U.S. Postsecondary Distance Learning Programs in the 1990s: A Decade of Growth," a research project of the Instructional Telecommunications Consortium/American Association of Community and Junior Colleges (Washington, DC: American Association of Community and Junior Colleges, 1991).

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Bachelor's Degrees by Sex

These recent trends in earned degrees for S&E fields show a similar pattern for both males and females, with a few exceptions in the social sciences and engineering. After 1993, degrees earned by males decreased slightly in the social sciences, while females maintained their high number of degrees in these fields. In engineering, females increased their earned degrees in the 1990s, particularly in chemical and civil engineering. In the same period, degrees in engineering earned by males declined slightly. (See figure 2-12.)

Over the past two decades, the proportion of S&E degrees earned by females has increased considerably, particularly in the natural sciences and engineering. In 1975, females earned about one-quarter of the degrees in the natural sciences and 2 percent of those in engineering. By 1995, females earned 59 percent of social science degrees, 47 percent of natural science degrees, 35 percent of mathematics and computer science degrees, and 17 percent of the engineering degrees. (See appendix table 2-20.)

Bachelor's Degrees by Race/Ethnicity/Citizenship

Trends in S&E bachelor's degrees also differ by race ethnicity, with white students earning fewer degrees in 1995 than in earlier years, and minority groups continuing their growth in earned degrees in these fields. The number of degrees earned by white students is slowly decreasing in all fields except the natural sciences.

In contrast, the number of degrees earned by underrepresented minorities in the United States—blacks, Hispanics, and Native Americans—is increasing slightly in NS&E fields and very rapidly in the social sciences. (See "S&E Human Capital Development: Continued Unevenness Across Demographic Groups.") In addition, the number of degrees earned by Asian Americans is increasing sharply in the natural and social sciences. (See appendix table 2-21.)

Foreign students have increased their earned degrees in the social sciences, but since 1981 have sharply decreased their degrees in engineering from U.S. institutions, as discussed in more detail below. The capacity to educate engineering students at the undergraduate level has increased dramatically in other world regions, and fewer foreign students are using U.S. universities for engineering education.

Participation Rates by Sex and Race/Ethnicity

The United States is one of the leaders in the world in providing access to higher education and ranks high among the major industrialized countries in the proportion of its population with an S&E background. These national statistics, however, do not apply to all fields or to all minority groups. In 1995, for the country as a whole, over 32 percent of the college-age population had completed a bachelor's degree in some field, and over 5 percent had earned a bachelor's degree in an NS&E field. But in that same year, only about 15 percent of black and Hispanic youth earned a college degree, and only about 2 percent of black and Hispanic youth earned a bachelor's degree in an NS&E field. In contrast, Asian

S&E Human Capital Development: Continued Unevenness Across Demographic Groups

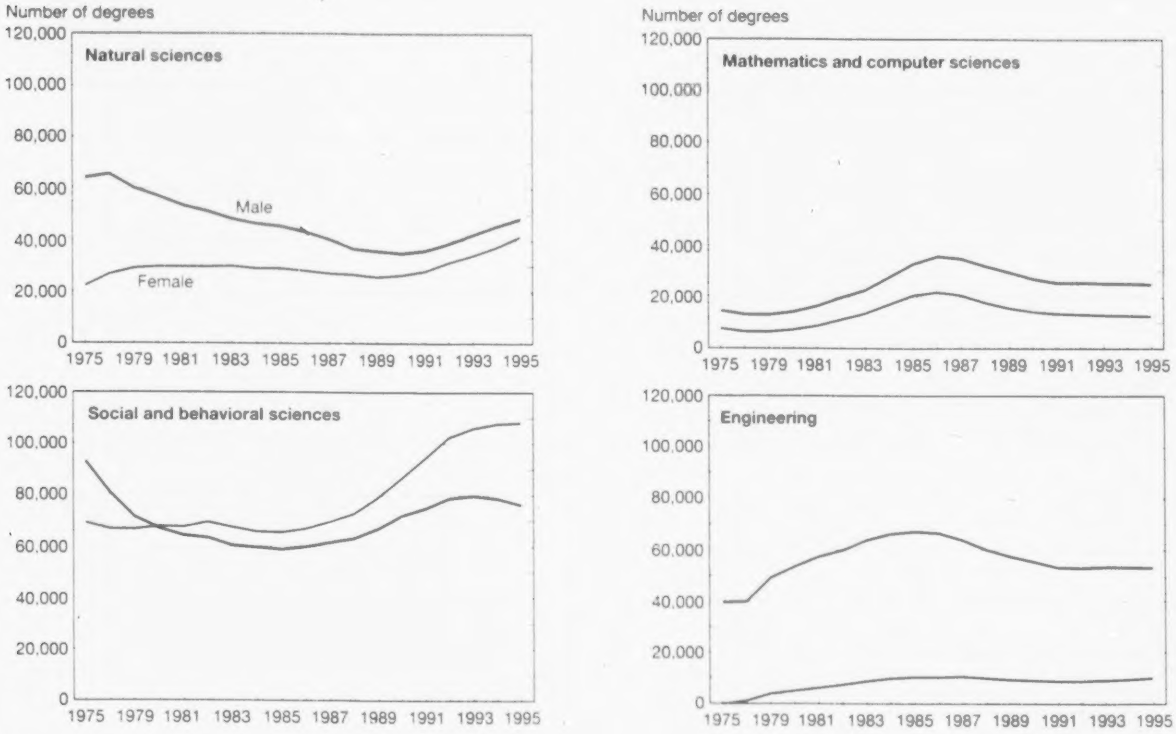
Beginning in the early 1980s, increasing numbers of women and minorities entered U.S. higher education. For a decade, the broadened entry of these groups fueled the expansion of enrollment in U.S. higher education and helped offset the trend of a declining U.S. college-age cohort. However, this broader access and increased enrollment in higher education did not concurrently result in larger numbers of S&E degree completions for women and minorities in all S&E fields at all levels. The pattern of participation is stronger in overall enrollment than in completed S&E degrees, stronger for females than for males in all underrepresented minority groups, stronger at the undergraduate than graduate level, and stronger in the natural and social sciences than in computer sciences and engineering.

Women. In the last decade, women achieved a higher rate of growth in undergraduate enrollment than men, particularly women in minority populations. Women now constitute 56 percent of undergraduate enrollment and an even higher percentage among minority populations. Women of every racial/ethnic group are increasingly choosing majors in the natural sciences and social sciences. At the bachelor's level, women now earn over half of the social science degrees and almost half of natural science degrees. However, women are less fully represented at the graduate level; in 1995, they accounted for 38 percent of total graduate enrollment. Women earned the majority of master's degrees in the social sciences and 41 percent of the master's degrees in the natural sciences. Women are least fully represented at the doctoral level. While women earn half of the doctoral degrees in the social sciences and 32 percent of the degrees in the natural sciences, they earn only 20 percent of the doctoral degrees in mathematics and computer sciences and less than 12 percent of doctoral engineering degrees.

Underrepresented minorities. The trend of increasing enrollment in undergraduate programs by underrepresented minorities has persisted for over a decade and accelerated in the 1990s, particularly for Hispanic populations. While minority groups indicate high aspirations to study S&E (as measured by freshman intentions), a substantial fall-off occurs between freshman declaration of intent and actual degree completion. This fall-off is greater for underrepresented minorities than for the majority population. Women and minority students are more likely to report a need for remedial work in mathematics and science than the majority male population. (Chapter 1 further discusses the large gap between minority students and the overall student population in number of science and mathematics courses taken.) There has been modest progress in minority participation in S&E degree completions. From 1975 to 1995, S&E bachelor's degrees earned by minorities increased from 6 to 8 percent of total such degrees. (Underrepresented minorities are around 28 percent of the college-age cohort.) Only about 2 percent of the 24-year-olds in underrepresented minority populations hold a bachelor's degree in NS&E—less than half the rate of the majority white population.

Progress for underrepresented minorities in S&E graduate enrollment has been very modest. In 1975, they accounted for 3.7 percent of S&E graduate enrollment; by 1995, they accounted for 5.0 percent. Minority students are underrepresented in S&E graduate degrees. They earn 7 percent of the master's degrees in S&E fields and less than 5 percent of the doctoral degrees. Women in these minority groups earn the majority of these degrees. (See NSF 1996f for disaggregated degree data by sex within each racial/ethnic group.)

Figure 2-12.
Bachelor's degrees awarded in S&E, by sex



See appendix table 2-20.

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Americans, representing only 4 percent of the U.S. population, have considerably higher than average participation rates: almost 40 percent obtained a bachelor's degree, and over 12 percent earned such a degree in NS&E.

Recent participation rates do show some progress toward more diversity in higher education in general and in S&E fields, compared with 1980 and 1990 data. (See text table 2-5.) Low participation rates for blacks and Hispanics changed little throughout the 1980s, although they improved considerably in the 1990s, particularly in the social sciences. In 1995, 3.8 percent of the U.S. female population earned an NS&E degree, compared to 2.1 percent in 1980.

U.S. Students Studying Abroad

A recent study highlights the core elements of an international education that will be important for American youth preparing to work in the global economy of the 21st century (IIE 1997). Referred to as "transnational competence," this education involves a combination of cultural and technical skills, including:

- knowledge of commercial, technical, and cultural developments in a variety of locales;
- understanding of local customs and negotiating strategies;
- facility with English and at least one other major language;
- facility with computers; and
- skills in technology and awareness of their different cultural contexts.

The United States has traditionally been weak in providing foreign language instruction. More recently, however, universities are improving undergraduate education by attempting to provide meaningful international experience as an integral part of coursework. (See "International Engineering Programs in the United States.") While there are no national data on the short-term visits conducted under such enhanced undergraduate curricula, the number of courses taken for credit overseas have increased, including engineering courses. (See text table 2-6.)

Graduate S&E Students and Degrees in the United States

Trends in Graduate Enrollment

Enrollment in U.S. graduate S&E programs grew for almost 20 years, reached a peak of almost 440,000 students in 1993, and then began to shrink. From 1975 to 1993, the total number of students in graduate programs increased steadily

Text table 2-5.
Percentage of 24-year-olds earning first university degrees in S&E, by sex and race/ethnicity

Sex and race/ethnicity	Total 24-year-old population	Total first university degrees	Natural science degrees	Social science degrees	Engineering degrees	With first university degree	With NS&E degree	With social science degree
				1980				
Total	4,263,800	940,251	110,253	138,682	58,810	22.1	4.0	3.2
Male	2,072,207	477,750	71,346	67,009	52,858	23.1	6.0	3.2
Female	2,191,593	462,501	38,305	68,623	5,952	21.1	2.1	3.1
White	3,457,800	807,509	100,704	151,839	60,856	23.4	4.7	4.4
Asian	64,000	48,908	3,467	3,039	3,866	29.5	10.2	4.8
Black	545,000	60,779	4,032	16,388	2,449	11.1	1.4	3.0
Hispanic	317,200	30,167	3,646	7,641	1,820	10.5	1.7	2.4
Native American	29,800	3,693	337	898	195	12.1	1.8	3.0
				1995				
Total	3,576,400	1,062,151	123,647	207,032	63,330	32.8	5.4	5.8
Male	1,817,400	495,867	66,540	76,256	52,421	29.2	6.9	4.2
Female	1,759,000	566,284	55,925	108,056	10,850	36.6	3.8	6.2
White	2,863,400	856,686	84,675	156,472	43,726	31.2	4.8	5.5
Asian	148,600	30,027	12,007	10,336	6,785	39.9	12.7	7.0
Black	527,600	59,301	8,021	16,662	2,845	16.2	2.1	3.2
Hispanic	466,800	43,894	6,119	12,420	3,651	14.2	2.1	2.7
Native American	37,000	4,212	676	1,230	221	17.4	2.4	3.3

NS&E = natural sciences and engineering

NOTE: Population data are for U.S. residents only and exclude members of the armed forces living abroad.

SOURCE: U.S. Bureau of the Census, Current Population Reports, series P-25, Nos. 519 and 917 (Washington, DC)

See appendix tables 2-20 and 2-21.

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Text table 2-6.
U.S. students studying abroad, by field of study

		Percentage studying					
	Total students studying abroad	All S&E fields	Physical sciences	Math & computer sciences	Agriculture	Engineering	Social sciences & humanities
1987/88	62,341	19.9	2.5	1.2	0.8	1.4	14.0
1989/90	70,727	22.8	3.7	0.8	0.4	1.3	16.6
1993/94	76,302	46.7	5.3	1.1	0.9	2.3	37.1
1994/95	84,403	47.5	6.8	1.2	0.7	2.2	36.6

SOURCE: Institute of International Education, *Open Doors, 1995-1996: Report on International Education Exchange* (New York: 1996).

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at an average annual rate of 2 percent. Subsequent declining enrollment has averaged 1 percent annually. Fewer students enrolling in engineering, mathematics, and the computer sciences account for most of this decline. Engineering, mathematics, and computer science enrollment grew at a rate of almost 4 percent annually from 1975 to 1992, but declined 3 percent annually from 1992 to 1995. While a slightly increasing number of students continues to enroll in the social and natural sciences, the annual rate of increase in these fields slowed after 1992. Trends differ when examining subfields: a look at the natural sciences shows that graduate enrollment in the physical sciences has decreased, while enrollment in the biological sciences has increased (NSF 1996e).

Enrollment by Sex, Race/Ethnicity, and Citizenship

While there are fewer graduate students in science and engineering, U.S. students today are a more diverse group than in the past. In 1977, women represented only one-quarter of S&E graduate enrollment; by 1995, they accounted for 38 percent of enrollment. (See figure 2-13.) While women and minorities continued a decade-long trend of increased enrollment in graduate S&E programs in 1993, enrollment figures for foreign students and U.S. white males began a downward trend. (See figure 2-14.)

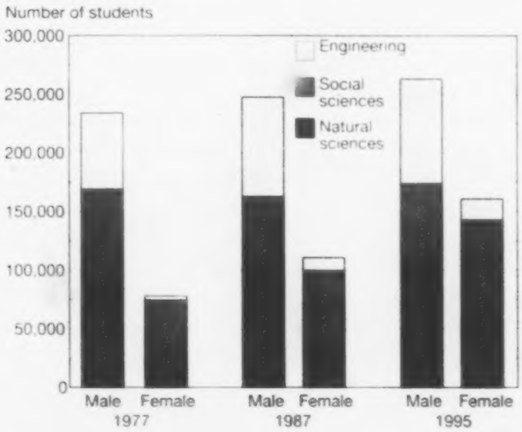
In 1992, foreign graduate students reversed their decade-long trend of increased S&E enrollment in U.S. institutions.

International Engineering Programs in the United States

International engineering programs (IEPs) allow U.S. students to gain valuable experience in an international setting. Traditional engineering curricula have been too tight and structured to allow engineering students to study abroad. IEPs, however, are customized to permit such study. A University of Cincinnati survey of universities with IEPs listed on the World Wide Web shows study abroad and work abroad components integrated into the engineering programs of about 25 major U.S. universities. A well-structured IEP gives students an opportunity to examine engineering in a foreign culture.

To promote the creation of IEPs, several universities in the United States and abroad are affiliated with the International Engineering Consortium. The consortium conducts a broad range of university-industry cooperative programs and continuing education programs. Members of academia and industry meet to discuss leading-edge technology, issues vital to the information age, and the nature of today's global marketplace. (For more information, see <<http://www.iec.org>>.)

Figure 2-13.
Graduate enrollment in S&E, by sex



NOTE: Natural sciences here include mathematics and computer sciences.

See appendix table 2-24. *Science & Engineering Indicators – 1998*

They decreased their enrollment each year since then. From 1983 to 1992, the number of foreign graduate students increased over 5 percent annually. From 1992 to 1995, their numbers decreased more than 3 percent annually. (See appendix table 2-25.)

The field of engineering illustrates both decreasing enrollment and increasing diversity. The number of students enrolled in graduate programs in engineering declined from approximately 118,000 in 1992 to less than 108,000 in 1995. But 1995 enrollment included almost 1,000 more women and 1,000 more underrepresented minorities than in 1992. One factor in the increasing enrollment of minorities in graduate S&E programs may be changing demographics—the higher growth rate in the minority population relative to the white population. The approximately 10,000-person decrease in engineering students from 1992 to 1995 was primarily due to declining numbers of foreign students and U.S. white males. In 1995, the number of foreign students represented about one-third of U.S. graduate enrollment in engineering, down from a peak of 34 percent in 1992. (See figure 2-15 for the declining enrollment of foreign students in graduate engineering.)

The recent decline in foreign students is likely influenced by the increasing educational opportunities in other countries. The growing capacity for S&E graduate education in Asian countries is shown not only in the expansion of higher education institutions in Asia (see "Growth in Institutions of Higher Education in Asia"), but also in the high rate of growth in earned doctoral degrees within Asian universities. (See appendix table 2-26.)

Foreign Students in All Levels of U.S. Higher Education

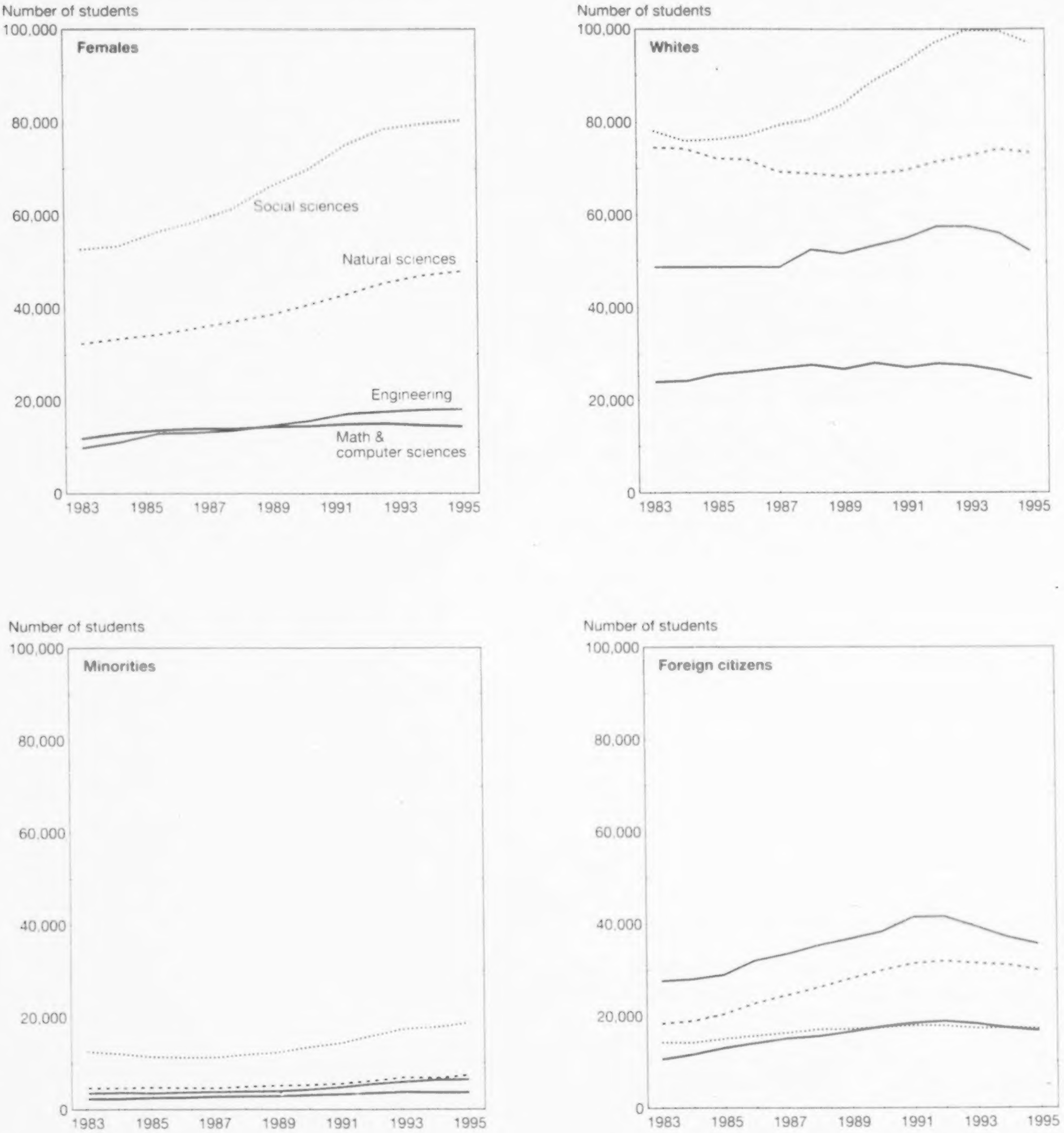
The majority of foreign students in the United States come from a small group of countries. Twelve leading countries of origin account for over 60 percent of the approximately 450,000 foreign students enrolled in U.S. higher education. Students from Asian countries—the most significant region of origin of foreign students in U.S. institutions—come to study at both the graduate and undergraduate levels. (See text table 2-7.) Students from China and India come to study mainly at the graduate level and overwhelmingly in NS&E fields. In contrast, students from Japan enroll mainly at the undergraduate level for non-S&E fields such as business administration. Enrollments of students from South Korea and Taiwan are more equally divided among graduate and undergraduate programs. Undergraduate students from South Korea and Taiwan in U.S. institutions study mainly non-S&E fields, while the majority of South Korean and Taiwanese graduate students enter S&E fields. (See appendix table 2-34.)

Master's Degrees

Over the past two decades, the overall trends in science and engineering degrees at the master's level show an increase in the number of earned degrees throughout the 1980s, with even stronger growth in the 1990s. The recent growth is mainly accounted for by the rising numbers of earned degrees in the social sciences and engineering, with relatively stable numbers in the natural sciences, mathematics, and computer sciences.

Examining trends within each field highlights the variations among different time periods of the past 20 years. In natural science fields, after a slight downward trend in the

Figure 2-14.
Graduate S&E enrollment for selected groups



NOTES: Data for women are available for odd years only before 1988. Minority data are for groups underrepresented in S&E: blacks, Hispanics, and Native Americans.

See appendix tables 2-24 and 2-25.

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Text table 2-7.
Foreign student enrollment in U.S. higher education, by region of origin: 1995/96

Total, all regions	453,635
Africa	20,844
Asia	259,893
Europe	67,358
Latin America	47,253
Middle East	30,563
North America	23,644
Oceania	4,202

SOURCE: Institute of International Education, *Open Doors 1995-96: Report on International Educational Exchange* (New York: 1996).

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Text table 2-8.
Percentage of S&E master's degrees earned by minorities and foreign citizens

Race/ethnicity and citizenship	Natural sciences	Social sciences	Engineering
	1977		
Asian	2.6	1.7	4.5
Black	2.4	6.2	1.5
Hispanic	1.5	3.0	1.6
Native American	0.3	0.3	0.1
Foreign citizen	15.6	7.0	21.8
	1995		
Asian	7.8	2.7	9.0
Black	3.0	5.9	2.3
Hispanic	2.3	4.0	2.5
Native American	0.3	0.6	0.2
Foreign citizen	28.5	10.8	33.9

NOTE: Natural sciences here include math and computer sciences.

See appendix table 2-28. *Science & Engineering Indicators – 1998*

1980s, the number of graduate students successfully completing master's degrees increased in the 1990s. In mathematics and the computer sciences, the very strong growth rate in earned master's degrees in the 1980s (almost 8 percent annually) shifted to a more modest growth rate in the 1990s, about 2 percent. The slight downward trend in earned master's degrees in the social sciences turned around in 1989, with sharply increasing numbers of social science degrees since then. The rapid growth in engineering master's degrees after 1980 leveled off in 1989-91, increased from 1991 to 1994, and then again leveled off in 1994-95. (See appendix table 2-27.)

Master's Degrees by Sex

Over the 20-year period 1975 to 1995, males accounted for the strong growth in master's degrees in engineering, mathematics, and the computer sciences. Females were primarily responsible for the strong growth in social sciences; they also obtained a larger share of degrees in the natural sciences. However, the proportion of master's degrees earned by females increased considerably in the last two decades—not only in the natural sciences, but in engineering as well. In 1975, females earned 21.1 percent of the natural science degrees at the master's level and 2.5 percent of the engineering degrees. By 1995, females accounted for 41.0 percent of natural science degrees and 16.2 percent of engineering degrees. (See appendix table 2-27.)

Master's Degrees by Race/Ethnicity

In the 1990s, minority groups in the United States earned, in most cases, increasing numbers as well as increasing shares of master's degrees in S&E fields. The number of S&E degrees earned by Asian Americans consistently increased, especially in engineering, mathematics, and the computer sciences. The number of S&E master's degrees obtained by blacks grew modestly in most fields, with strong growth in the social sciences. Despite gains in individual S&E fields, the overall share of master's degrees in S&E earned by black students declined slightly from 1977 to 1995. Hispanics earned a modestly increasing number—and proportion—of degrees in the social sciences, as well as in engineering. White students showed modest growth in NS&E degrees earned in the 1990s, and strong growth in social science. Notwithstanding these gains, the share of master's degrees earned by white students in all fields declined during the 1977-95 period. (See text table 2-8 and appendix table 2-28.)

Master's Degrees by Citizenship

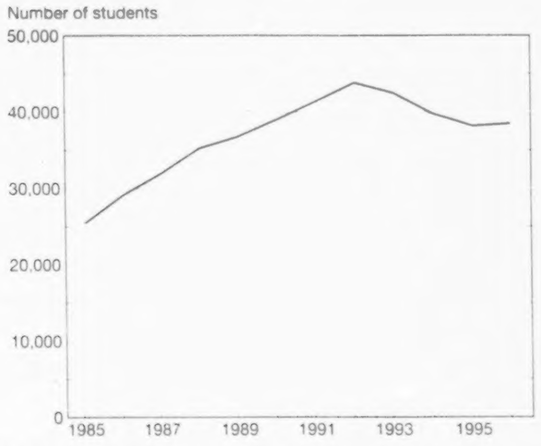
Analysis of master's degrees by citizenship shows a continuation of the trend toward a larger proportion of degrees going to foreign students in engineering, mathematics, and the computer sciences. In 1975, foreign students earned 21.8 percent of the engineering degrees and 11.3 percent of the math and computer science degrees. By 1995, foreign representation at the master's level was 33.9 percent in engineering and 34.7 percent in math and computer sciences. (See appendix table 2-28.)

However, the rate of growth of overall S&E master's degrees obtained by foreign students slowed somewhat in the 1993-95 period, primarily because of the leveling off in their earned degrees in mathematics and computer sciences. There is as yet no evidence of declining numbers of engineering degrees awarded to foreign students, even though foreign graduate enrollment in engineering decreased from 1993 to 1995 and leveled off in 1996. (See figure 2-15.)

Doctoral Degrees

From 1975 to 1985, the number of S&E doctoral degrees granted in the United States was relatively stable. After 1985, however, the number of such degrees grew, reaching over 26,000 by 1995. (See figure 2-16.) Large increases in the number of earned degrees occurred mainly in engineering, mathematics, and computer sciences. The number of degrees in these fields nearly doubled from 1985 to 1995. Natural science fields—

Figure 2-15.
Foreign student enrollment in graduate engineering programs



See appendix table 2-29. *Science & Engineering Indicators – 1998*

particularly the biological sciences—also contributed to the rising number of degrees, with a 30 percent increase.

Doctoral Degrees by Sex

Male doctoral degree recipients accounted for much of the growth in engineering, mathematics, and computer sciences, while female doctoral recipients were largely responsible for the increasing number of natural science degrees.

Within the past two decades, the share of S&E doctoral degrees earned by women doubled from 15.6 percent in 1975 to 31.2 percent in 1995. The proportion has differed by field. By 1995, females earned almost half of the doctoral degrees in the social sciences and 38 percent in the biological sciences. (See appendix table 2-30.) Growth in the proportion of degrees awarded to women was greatest in engineering subfields. By 1995, women earned almost 12 percent of all engineering doctorates, and 15 to 16 percent of doctoral degrees in chemical and materials engineering.

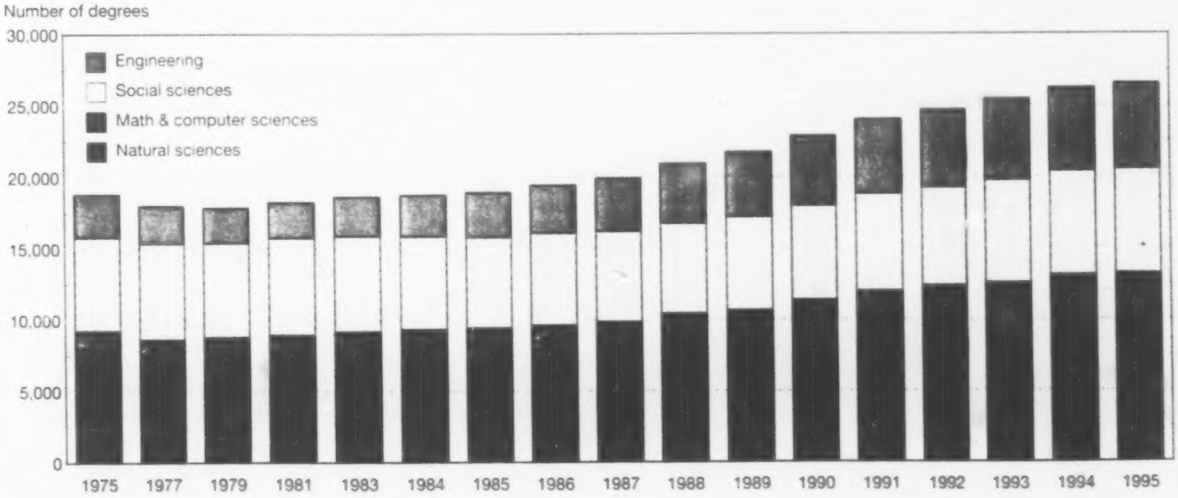
Doctoral Degrees by Race/Ethnicity

Underrepresented minorities within U.S. universities received almost 5 percent of all S&E doctorates awarded in 1995, up slightly from 3 percent in 1977. As a group, these minorities accounted for 8 percent of earned degrees in the social sciences, 4 percent in the natural sciences, 3 percent in engineering, and 2 percent in mathematics and the computer sciences. For black Ph.D. recipients, the largest numerical increases in the past decade have been in the biological and social sciences. The largest percentage increases have been in the biological sciences and engineering. (See appendix table 2-31 and NSF 1996d.)

Foreign Doctoral Students in the United States

In the past decade, foreign students have accounted for the large growth in S&E doctoral awards in U.S. universities. The number of foreign doctoral recipients in U.S. universities doubled in S&E fields from over 5,000 in 1986 to over 10,000 in 1995. This doubling translates to an 8.2 percent average annual increase. In contrast, the rate of increase in doctoral de-

Figure 2-16.
S&E doctoral degrees awarded by U.S. universities



NOTE: Doctoral degree data are available for odd years only before 1984.

See appendix table 2-30. *Science & Engineering Indicators – 1998*

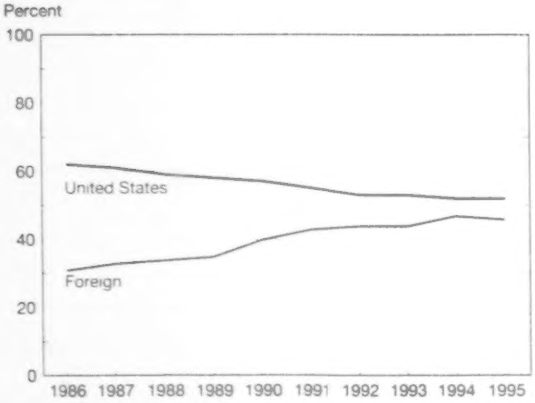
grees to U.S. citizens averaged only 1.9 percent annually.

Within NS&E fields, the proportion of doctoral degrees earned in U.S. universities by foreign citizens climbed from 31 percent in 1986 to 47 percent in 1994; it has since begun to level off. (See figure 2-17.) Foreign students from China, India, South Korea, and Taiwan have played a central role in this growth. In 1995, foreign doctoral recipients from these four Asian economies accounted for 59 percent of all S&E doctorates earned by foreign students (NSF 1996d). In 1995, the share of NS&E degrees earned by foreign students decreased slightly to 46 percent, mainly due to a decline in doctoral degrees earned by South Korean and Taiwanese students. Both of these economies (which are major contributors of foreign graduate students in the United States) have increased their internal capacity for graduate education in science and engineering, evidenced by the increasing number of in-country doctoral degrees in these fields. (See appendix table 2-36.)

Even as Asian students entered U.S. graduate programs in record numbers, Asian universities were expanding their own doctoral degree programs in S&E fields. In fact, the two phenomena are related. The desire to increase their within-country capacity to educate their students through the doctoral level required sending students abroad as a way of preparing more S&E faculty for expanded graduate programs within Asian universities. In the period 1988-94, the Asian effort to receive doctoral training in U.S. universities was particularly intense, as evidenced by an increase from 2,872 earned degrees in 1989 to 6,229 in 1994. The annual rate of growth in earned S&E doctoral degrees during this period was over 17 percent. This rate of growth has slowed considerably in the last few years, however.

Students from Asian countries are becoming less dependent on U.S. universities for their doctoral training. After 1993, the annual rate of increase in the number of earned S&E doctoral degrees within Asian universities greatly exceeded the growth in degrees earned by Asian foreign students within U.S. universities. (See figure 2-18.) While Ph.D. production in S&E fields is growing at a faster rate in Asian countries than in the United States, it should be noted that the base is lower. In 1995, total doctoral degrees in S&E earned in six Asian countries numbered 15,700. In that same year, U.S. universities produced over 26,000 doctoral S&E degrees; over 6,000 of these degrees were earned by foreign students from Asia. (NSF 1996e). In 1995, the number of doctoral NS&E degrees earned from universities within four Asian economies exceeded the number of such degrees earned by Asian foreign students within U.S. universities. Only for Taiwan do U.S.-earned NS&E doctoral degrees outnumber those earned within Taiwanese universities. However, in engineering, China, India, and South Korea still obtain more doctoral degrees from U.S. universities than from their home country universities. (See text table 2-9.)

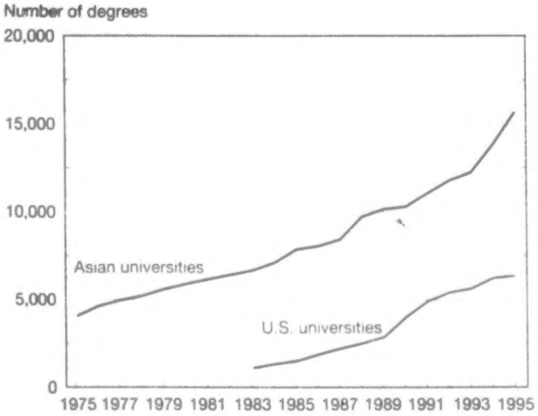
Figure 2-17.
NS&E doctoral degrees awarded by U.S. universities to U.S. and foreign citizens



NOTE: Foreign students include those on either temporary or permanent visas.

See appendix table 2-35. *Science & Engineering Indicators – 1998*

Figure 2-18.
S&E doctoral degrees awarded to Asian students by Asian and U.S. universities



NOTE: Data for U.S. universities are not available before 1983.

See appendix table 2-36. *Science & Engineering Indicators – 1998*

Besides providing doctoral training to foreign students from Asia, U.S. higher education is also linked to expansion of Asian capacity in S&E education through institution building. Leading research universities in the United States are advising developing countries in their design of higher education in science and engineering. For example, the Massachusetts Institute of Technology has accepted an agreement to create a scientific research university in Malaysia (Sales 1997).

Stay Rates of Foreign Doctoral Recipients in the United States

Until 1992, around half of the foreign students who earned doctoral degrees in S&E in U.S. universities planned to locate in the United States after completing their degrees. A

Text table 2-9.
NS&E doctoral degrees awarded to Asian students by Asian and U.S. universities: 1995

Student place of origin	Within country Ph.D. in:		U.S. university Ph.D. in:	
	Natural sciences	Engineering	Natural sciences	Engineering
Five-country total	8,576	6,327	2,335	3,268
China	1,373	1,659	773	1,802
India	4,077	348	572	499
Japan	2,143	3,009	30	51
South Korea	750	938	344	414
Taiwan	233	373	616	502

NS&E = natural sciences and engineering

SOURCES: **China**—National Research Center for Science and Technology for Development, unpublished tabulations, 1996; **India**—Department of Science and Technology, *Research and Development Statistics 1994-95* (New Delhi: 1996); **Japan**—Monbusho, *Monbusho Survey of Education* (Tokyo: annual series); **South Korea**—Ministry of Education. *Statistical Yearbook of Education* (Seoul: 1996); **Taiwan**—*Educational Statistics of the Republic of China* (Taipei: 1996); **United States**—National Science Foundation, Science Resources Studies Division, *Selected Data on Science and Engineering Doctorate Awards: 1995*, NSF 96-303 (Arlington, VA: 1996).

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significantly smaller proportion (one-third) received firm offers to remain in the United States for academic or industrial employment. The proportion of foreign doctoral recipients who plan to locate in the United States and accept firm offers differs considerably by country and region. Students from Asian countries, who are the most numerous, are the most likely to stay in the United States. In contrast, of the less numerous students from North and South American countries, fewer plan to locate in the United States.

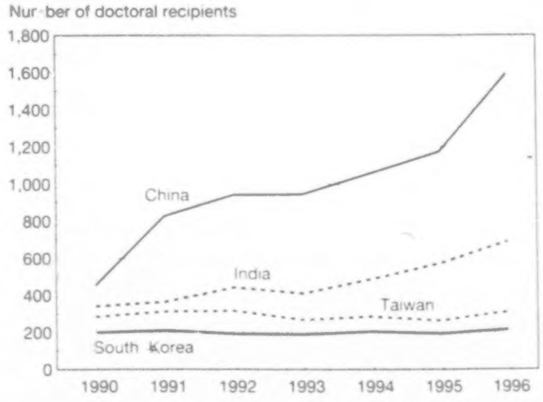
For the period 1992-96, the percentages of foreign S&E doctoral recipients planning to remain in the United States increased: over 68 percent planned to locate in the United States, and nearly 44 percent had firm offers to do so. This recent increase in stay rates, which may be temporary, is mainly accounted for by the sharp increase in the percentage of Chinese students with firm plans to stay in the United States. In 1990, 42 percent of over 1,000 Chinese S&E doctoral recipients in U.S. universities had firm plans to stay. By 1996, 57 percent of the nearly 3,000 Chinese S&E doctoral recipients from U.S. universities had firm plans to remain in the United States. The underlying cause for this shift is the large number of Chinese students granted permanent residence status in the United States in 1992 following China's response to student demonstrations. In 1996, students from selected countries in Europe also increased their stay rates after completing advanced S&E degrees from a U.S. university, but their numbers are small in comparison to Asian countries: 61 from the United Kingdom and 75 from Germany. (See appendix table 2-37.)

Among Asian countries, China and India apparently have a limited capacity to provide high-level employment to large numbers of returning recipients of doctoral degrees in science and engineering. In 1996, 57 and 59 percent, respectively, of the U.S. S&E doctoral recipients from these countries choose to accept employment in the United States. (See appendix table 2-37.) In contrast, only 24 percent of 1996 doctoral recipients from South Korea and 28 percent from Taiwan accepted employment offers in the United States. The trend in the 1990s has been for fewer doctoral recipients from these economies to remain in the United States because of within-country employment opportunities; this is particularly true of South Korean engineering doctoral recipients. (See figure 2-19.)

To a large extent, the definite plans of foreign S&E doctoral recipients to remain in the United States revolve around postdoctoral study rather than employment. Between 1988 and 1995, individuals from the five economies with the largest numbers of foreign doctoral recipients cited further study as their main reason to stay in the United States (58 percent), followed by employment in R&D (27 percent), teaching (7 percent) and other professional employment (8 percent). (See text table 2-10.)

A recent study of foreign doctoral recipients working and earning wages in the United States (Finn, 1997) shows that about 47 percent of the foreign students who earned S&E doctorates in 1990 and 1991 were working in the United States in 1995. The percentages are higher in physical sciences and engineering, and lower in the life sciences and social sciences. (See chapter 3, "Stay Rates of Foreign Recipients of U.S. Ph.Ds.") These stay rates differ more by country of origin than by discipline, however. The majority of the 1990-91 foreign S&E doctoral recipients from India (79 percent) and China (88 percent) were still working in the United States in

Figure 2-19.
Asian recipients of NS&E doctorates from U.S. universities with firm plans to stay in the United States



See appendix table 2-37. *Science & Engineering Indicators – 1998*

Text table 2-10.
Foreign recipients of S&E doctorates from U.S. universities with definite plans to remain in the United States: 1988-95

			Primary activity			
Place of origin	Total S&E doctoral recipients	Total definitely planning to remain	Post-doctoral study	R&D	Teaching	Other Professional
Canada	2,111	897	449	235	98	115
China	13,598	6,238	4,120	1,342	295	486
India	6,585	3,542	1,535	1,316	315	375
South Korea	7,872	1,765	1,324	266	121	55
Taiwan	8,778	2,411	1,197	863	145	208

SOURCE: National Science Foundation, Science Resources Studies Division, *Statistical Profile of Foreign Doctoral Recipients, by Major Country of Origin* (Arlington, VA: 1998, forthcoming).

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1995. In contrast, only 10 percent of South Koreans who completed engineering doctorates from U.S. universities in 1990-91 were working in the United States in 1995. (See appendix table 2-38.)

The same study looked at foreign doctoral recipients from 1970 to 1972. Finn estimated that 47 percent were working in the United States in 1995, and that the stay rate for that group had fluctuated around 50 percent during the 15 years leading up to 1995. There is no evidence of significant net return migration of these scientists and engineers after 10 or 20 years of work experience in the United States. This does not mean that there is no significant return migration; in fact, such migration is known to occur. (See "Reverse Flow of Scientists and Engineers to Asia" later in this chapter.) However, the fairly constant stay rates indicate that any tendency of the 1970-72 cohorts to leave the United States after gaining work experience here has been largely offset by others from the same cohorts returning to the United States after going abroad.

Postdoctoral Appointments[10]

Postdoctoral research positions in science and engineering in U.S. universities increased 5 percent annually from the mid-1980s, and continued this rate of growth until 1994. Most of the growth in the number of postdoctoral appointments, which reached almost 26,000 in 1994, can be accounted for by the expansion of research performed by universities and the concomitant increase in earned doctoral degrees. From 1985 to 1994, funding of research performed by U.S. universities increased at almost $1 billion a year in constant dollars, from a base of $10 billion. (See chapter 4.) However, in 1995 the rate of increase in the availability of postdoctoral appointments slowed considerably, dropping to only 1 percent. In that year, R&D expenditures for university-performed research also stabilized.

During the period of rapid growth in S&E postdoctoral appointments, foreign students earned an increasing proportion both of doctoral degrees and of subsequent postdoctoral appointments. From 1990 to 1994, U.S. universities provided slightly more than half of their postdoctoral appointments to non-U.S. citizens. During this period, the growth rate of domestic postdoctoral appointments was about 4 percent. However, like the recent decline of foreign graduate enrollments in science and engineering in U.S. universities since 1993, there has been a slightly smaller proportion of foreign postdoctoral appointments and a slightly increasing number of appointments to U.S. citizens, particularly in the sciences. Foreign postdoctoral recipients still receive the majority of such research positions within U.S. universities in engineering. (See appendix table 2-39 and chapter 3, "Postdoctorate Appointments.")

Mobility is a characteristic of postdoctoral researchers throughout the world, however. Foreign scientists and engineers represent approximately 50 percent of the postdoctoral pool in the United States; the United Kingdom and France have a high percentage of foreign postdoctorates as well, although the number of postdoctoral positions in these countries is much smaller. In addition, Japan is attempting to improve the quality of its basic research at universities by offering more postdoctoral fellowships for both Japanese and foreign doctoral scientists and engineers.

Foreign Faculty in U.S. Higher Education

One indicator of mobility of S&E personnel in the world is the proportion of foreign-born faculty in U.S. higher education. The United States has been a magnet for trained scientists and engineers because of a well-developed economy able to absorb high-level personnel. (See chapter 3, "Foreign-Born Scientists and Engineers in the United States.") This section reviews data on those S&E faculty members in four-year colleges and universities who were born in another world region and whose primary job is teaching in an S&E field.[11]

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[10] The data reported here are from the National Science Foundation's Survey of Graduate Students and Postdoctorates in Science and Engineering (NSF 1997b), and include university postdoctoral appointments only; these account for about 70 percent of U.S. postdoctoral appointments. The remaining 30 percent of such appointments are made by the National Institutes of Health, federal research laboratories, and private companies. Data on such appointments are not captured by this survey.

The U.S. university system has been able to employ considerable numbers of foreign-born scientists and engineers. In 1993, foreign-born faculty in U.S. higher education represented 37 percent of the engineering professors and 27 percent of the mathematics and computer science teachers. (See figure 2-20.) These faculty are mainly from Asia and Europe, with the largest numbers coming from India, China, the United Kingdom, Taiwan, Canada, and South Korea. (See text table 2-11.)

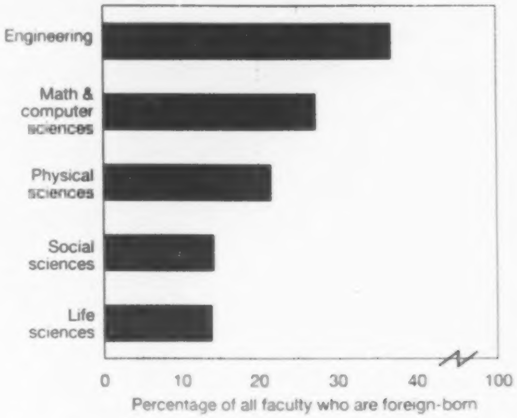
Reverse Flow of Scientists and Engineers to Asia

In the past decade, Asian foreign students—mainly from China, India, South Korea, and Taiwan—have earned nearly 45,000 doctoral degrees in S&E within U.S. universities. (See appendix table 2-43 and text table 2-12.) Compared to these major Asian countries of origin, the number of students from Singapore and Japan earning doctoral degrees in the United States is relatively small. Japanese industries often finance advanced training of their employees in U.S. universities for one to two years, but relatively few remain long enough to complete a doctoral program (NSF 1997c).

As mentioned above, a considerable number of doctoral recipients from Asian countries have received firm offers to remain in the United States. These Asian scientists and engineers have contributed significantly to the U.S. university system. In 1993, Asian-born faculty in U.S. higher education represented 19.7 percent of the faculty in engineering, 9.6 percent in the physical sciences, and 12.5 percent in mathematics and computer sciences. (See appendix table 2-40.) They have also contributed to U.S. industry as R&D personnel and by starting new companies. Immigrant scientists and engineers make up 28 percent of the S&E labor force in the United States (NSF 1995b). Many Asian scientists working in the United States participate in communication networks with home-country scientists. The dramatic growth in Asian economies has provided U.S.-based Asian scientists and engineers with more opportunities for cooperative research and consulting (Choi 1995).

The decision of foreign doctoral recipients to remain and work in the United States or to return home relates to job opportunities in their home country. Some dynamic Asian economies are gaining the capacity to absorb high-level S&E personnel. For example, foreign doctoral recipients from Taiwan, South Korea, and Hong Kong are successfully recruited to S&E positions within their home economies. In contrast, a high proportion of foreign doctoral recipients from India and China remains in the United States, since these countries currently have a limited capacity to offer high-level S&E employment to the 14,000 scientists and 7,500 engineers from these countries who have been educated in the United States in the last 10 years. (See appendix table 2-43.)

Figure 2-20.
Foreign-born S&E faculty in U.S. higher education, by field: 1993



See appendix table 2-40. *Science & Engineering Indicators – 1998*

In the 1990s, Asian-born scientists and engineers working in the United States have begun a small reverse flow from West to East. Some are attracted by new or expanded research facilities based in their home countries; these facilities are often part of the country's strong investment in R&D infrastructure as a strategy to develop indigenous high technolo-

Text table 2-11.
Major countries of origin of foreign-born S&E faculty members in U.S. universities: 1993

Place of origin	Number	Percentage
Total S&E faculty	242,812	100.0
U.S.-born	193,606	79.7
Foreign-born[a]	49,206	20.3
S&E faculty from major countries of origin	23,762	9.8
India	5,696	2.3
China	4,263	1.8
United Kingdom	3,149	1.3
Taiwan	2,491	1.0
Canada	2,206	0.9
South Korea	2,163	0.9
Germany	1,604	0.7
Iran	1,369	0.6
Greece	821	0.3
Other	25,446	10.5

[a] This includes scientists and engineers whose first job is in S&E postsecondary teaching at four-year colleges and universities in the United States; it excludes scientists and engineers who may teach as a secondary job.

See appendix tables 2-40 and 2-42.

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[11] These data exclude S&E faculty members who teach in two-year and community colleges or who teach in an S&E field as a secondary job.

Text table 2-12.
S&E doctoral degrees awarded to Asian students by U.S. universities

Place of origin	Cumulative 1986-95
Total Asia	44,931
China	14,088
Hong Kong	952
India	7,554
Japan	1,276
South Korea	8,821
Taiwan	10,276
Thailand	956
Other Asia	1,008

See appendix table 2-43. *Science & Engineering Indicators – 1998*

gies. By 1992, the combined R&D investments of six Asian countries reached almost $100 billion in constant dollar terms, up from $35 billion in 1982 (NSF 1993).

Asian countries offer opportunities for high-level employment in science as well as expanding R&D budgets that can fund the majority of proposed research within these countries. Taiwan has been able to recruit senior scientists and engineers who had previously emigrated to the United States as students and young scientists. In the late 1980s, returnees with science degrees numbered between 500 and 1,000 per year. These scientists, including some Nobel prize winners, were hired in Taiwan as senior faculty for expanding graduate programs and as laboratory directors, particularly at centers of excellence such as the Synchrotron Center in Hsinchi Science Park. (see "Chinese Students Drawn Back to Asia," 1996). The increasingly large numbers of Taiwan returnees with science degrees—over 2,000 per year—are, since 1992, competing for fewer jobs; S&E positions in government and universities, except for the newly established East China University, have largely been filled with early returnees. The Taiwanese government is providing two-year postdoctoral appointments within high-technology industries to many recent returnees. These high-technology industries, however, are hiring permanently only in targeted areas in which there is a scarcity of trained S&E personnel, such as superconductivity, and solid-state industries.

Newly established Asian universities have successfully begun to recruit Western-educated scientists and engineers to expanding S&E departments. For example, the large majority of Chinese and South Korean professors in the Hong Kong University of Science and Technology (HKUST) and South Korea's Pohang University of Science and Technology received their doctoral training in the United States. In addition to the large portion of U.S.-educated faculty in the major universities of Hong Kong, former U.S. faculty are the deans and heads of almost all of S&E departments and make up a large majority of the directors of HKUST research institutes. (See text table 2-13.)

Similarly, the National University of Singapore and its attached five research centers and six independent institutes are recruiting senior scientists from the United States as deans, department heads, and laboratory directors. Many Chinese-born U.S. scientists have been attracted to Singapore's world-class facilities and equipment, high salaries, generous research funding, and opportunity to contribute to the development of the Asian region through science and technology.

International Comparisons of S&E Training in Higher Education

International Comparison of Foreign Students

For many countries within the Asian region, the attraction of students to S&E is an important aspect of their economic growth strategy, including expanding access and participation of foreign students. Universities in Australia are aggressively recruiting foreign students, and the government is including the provision of educational services to Pacific Rim countries as part of its national economic planning. The long-range plan is to have 2.8 million foreign students by 2010

Text table 2-13.
Leading scientists and engineers in Hong Kong universities, by country of Ph.D. award: 1996

University	Total	United States	United Kingdom	Canada	Australia	Hong Kong
Hong Kong University of Science and Technology						
Deans/department heads	15	14	0	1	0	0
Directors/research centers	16	12	3	1	0	0
Chinese University of Hong Kong						
Full professors	16	6	4	3	1	2
Directors/research centers	10	4	3	1	0	2

SOURCES: The Hong Kong University of Science and Technology, *Academic Calendar 1996-1997* (Kowloon, Hong Kong: 1996); and Chinese University of Hong Kong, *Calendar 1996-1997* (New Territories, Hong Kong: 1996).

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Text table 2-14.
U.S. students studying in Japan

Study level	1995			1996		
	Total U.S. students studying in Japan	With Japanese scholarship	Without Japanese scholarship	Total U.S. students studying in Japan	With Japanese scholarship	Without Japanese scholarship
Undergraduate	692	1	691	729	0	729
Graduate	255	127	128	271	137	134
Other	140	68	72	88	38	50

NOTE: For a description of Japanese exchange programs, see << http://www.twics.com/~nsftokyo/home.html>>.

SOURCE: National Science Foundation, Tokyo Office, unpublished tabulations (1997).

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Text table 2-15.
Foreign student enrollment in higher education in the United States and selected European countries

Country	Year	Total enrollment	Number of foreign students	Percentage of total enrollment
United States	1985/86	12,670,121	349,610	2.8
	1995/96	14,419,252	453,787	3.1
France[a]	1985/86	960,084	131,979	13.7
	1995/96	1,463,371	129,761	8.9
Germany	1985/86	1,550,211	79,354	5.1
	1993/94	1,875,099	116,474	6.2
United Kingdom	1985/86	1,032,491	53,694	5.2
	1992/93	1,528,389	95,594	6.3

[a] French data are for universities only and do not include engineering schools, business schools, and professional schools.

SOURCES: UNESCO, *Statistical Yearbook* (Paris: 1996); Institute of International Education, *Open Doors 1995-1996: Report on International Education Exchange* (New York); and Ministère de l'Éducational Nationale, *Repères et Références Statistiques sur les Enseignements et la Formation* (Vanves, France: 1996).

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(Blight 1996). Japan currently educates 50,000 foreign students in its university system, mainly from China and South Korea. Through scholarships and fellowships, Japan seeks to double that number by the year 2000 (NSF 1997c). The number of U.S. students studying in Japan is growing, and includes many who have received Japanese scholarships. (See text table 2-14.) Taiwan, Singapore, Malaysia, and Hong Kong are replicating U.S. research universities and expanding their graduate S&E programs with Chinese students (Sales 1997).

Among European countries, foreign participation is attributable to a long-standing tradition of educating students from former colonies, as well as increased emphasis on European-wide exchanges. European countries have a higher percentage of foreign student enrollment than the United States when all levels of higher education are included. In 1995, foreign students accounted for between 6 and 9 percent of enrollment in higher education in selected European countries, compared to about 3 percent in the United States. (See text table 2-15.) Among European countries, universities in Germany and France—with minimal or no tuition required for higher education—are receiving an increasing number of Western and Central European students. Germany is attempting to build up the higher education institutions in the former East Germany and Central Europe. While the percentage of foreign students is relatively low, they are concentrated at the doctoral level in Europe and the United States.

International Comparison of Doctoral Training

Increasing global capacity in S&E education is evident at the advanced degree level. This section presents aspects of doctoral degree preparation among selected countries of Asia, Europe, and North America, including overall degree production and participation of women and foreign students.

Europe leads North America and Asia in number of earned S&E doctoral degrees. In 1995, doctoral degrees awarded in S&E fields by Western and Eastern European institutions totaled 45,647—about 60 percent higher than the North American level and almost three times as many as the number recorded for Asian countries. (See text table 2-16 and appendix table 2-32.)

Text table 2-16.
Doctoral S&E degrees awarded, by world region: 1995

Field	Three-region total	Asia	Europe	North America
Doctoral degrees, all fields	155,733	32,087	78,791	44,855
Science & engineering	89,818	15,678	45,647	28,493
Natural sciences	49,888	8,576	27,082	14,230
Social sciences	15,663	775	7,030	7,858
Engineering	24,267	6,327	11,535	6,405

NOTES: Natural sciences here include agricultural, mathematics and computer sciences. See appendix table 2-32 for countries included in each region.

See appendix table 2-32. *Science & Engineering Indicators – 1998*

Text table 2-17.
Share of doctoral S&E degrees earned by women in selected countries: 1995
(Percentages)

Field	United States	Germany	France[a]	United Kingdom	Japan[b]	South Korea	Taiwan
All S&E fields	31	22	NA	21	10	7	9
Natural sciences	32	26	35	34	11	13	17
Math & computer sciences	21	12	23	18	NA	13	13
Social sciences	50	34	45	33	25	10	23
Engineering	12	6	17	13	5	2	3

[a] In France, the natural sciences exclude the biological sciences, which are instead classified with health and medicine, and in which women earn 51 percent of the doctoral degrees. The social sciences include literature and the humanities.

[b] In Japan, mathematics and computer sciences are included in engineering. Percentages are based on university "coursework" doctoral degrees only, not those earned within industry.

SOURCES: **United States**—National Science Foundation, Science Resources Studies Division, *Selected Data on Science and Engineering Doctorate Awards 1995*, NSF 96-303 (Arlington, VA: 1996); **France**—Ministère de l'Éducation Nationale de l'Enseignement Supérieur et de la Recherche, *Rapport sur les Études Doctorales* (Paris: 1996); **Germany**—Statistisches Bundesamt Wiesbaden, *Prüfungen an Hochschulen* (Weisbaden: 1996); **United Kingdom**—Higher Education Statistics Agency, *Students in Higher Education Institutions, 1995/96* (Cheltenham: 1997); **Japan**—Monbusho, *Monbusho Survey of Education* (Tokyo: annual series); **South Korea**—Ministry of Education, *Stastistical Yearbook of Education* (Seoul: 1996); **Taiwan**—Ministry of Education, *Educational Statistics of the Republic of China* (Taipei: 1996).

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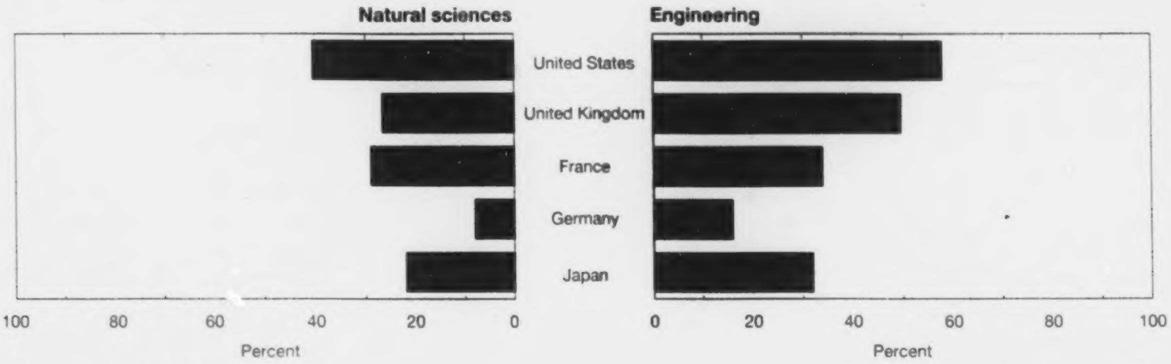
Figure 2-21.
Proportion of NS&E doctoral degrees earned by foreign students in selected countries: 1995 or most recent year



See appendix table 2-33.

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Comparing female representation in doctoral S&E degrees across countries, the United States ranks lower than France and higher than Germany. For example, within French universities in 1995, women earned a higher percentage of the NS&E doctoral degrees than did women in U.S. universities. (See text table 2-17.)

While graduate S&E programs are expanding rapidly in Asia, women have not yet entered those programs in large numbers. Women still earn only a small fraction of the doctoral S&E degrees issued in Asia. In fact, Asian women are more likely to obtain a doctoral degree in S&E fields from a U.S. university than from a home country university. For example, in 1995, women earned 7 percent of doctoral degrees in South Korea, but 12 percent of the doctoral degrees earned by South Koreans in the United States. For women from Taiwan, the figures were 9 and 16 percent, respectively (NSF 1996d).

The United States, the United Kingdom, and France are the world's leading countries in terms of foreign students in S&E at the doctoral level. For example, 57 percent of the engineering doctoral degrees awarded in the United States in 1995 went to foreign students. (See figure 2-21.) In that same year, almost 50 percent of the engineering doctoral degrees awarded in the United Kingdom, and almost 30 percent of those awarded by French universities in the natural sciences, were earned by foreign students.

Conclusion

Centers of S&E knowledge are multiplying around the world, particularly in Europe, Asia, and North America. The increasing global capacity in S&E education has implications for the United States as well as other nations. Higher participation rates in S&E degrees and a greater focus on S&E fields in higher education in other countries contribute to the potential pool of scientists and engineers. Such human capital is important for addressing complex societal needs and for technological innovations. In addition, the global expansion of S&E knowledge has the potential benefits of quickening the pace of development in other world regions. A larger global capacity for S&E education implies a U.S. need to stay competitive through continual improvement of its precollege and higher education system.

Decisionmakers throughout the U.S. higher education system have introduced improved curricula and teaching at the undergraduate level to broaden participation of all groups in science and engineering. Recent participation rates in S&E, disaggregated by race/ethnicity and sex, show some domestic progress compared to a decade ago; this reflects a somewhat more diverse U.S. student population pursuing higher education in science and engineering, particularly at the undergraduate level. In the 1990s, the number of white enrollments in undergraduate education leveled off and began to decline, while enrollment for all minority groups increased. Similarly, while overall undergraduate engineering enrollment has been declining, enrollment of women and minorities has been increasing, particularly in the 1990s. At the bachelor's level, the number of degrees earned by underrepresented minorities is increasing slightly in NS&E fields, and very rapidly in the social sciences. These trends bear watching as individual states introduce systemic reforms and other public policy changes for improved S&E curricula and teaching at all levels.

In graduate education, there has been some progress for women in S&E programs, and very slight progress for underrepresented minorities. At the master's level, women have made significant progress in earned degrees in the natural sciences, but minority groups showed only modest growth in these fields. At the doctoral level, the share of S&E degrees earned by women approximately doubled from 16 percent in 1975 to 31 percent in 1995. Minority students have slightly increased their proportion of doctoral S&E degrees to almost 5 percent in 1995, but they are still at low levels of degree attainment.

The enrollment of foreign S&E graduate students in U.S. universities reached a peak in 1992, and has since declined. The rate of growth in S&E master's degrees earned by foreign students has slowed in the 1990s due primarily to a decline in earned degrees in the computer sciences. However, declining graduate enrollment of foreign students in engineering has not yet resulted in a fall-off of the number of master's degrees in engineering earned by foreign students. At the doctoral level, the proportion of S&E degrees earned by foreign citizens reached 40 percent in 1994 before leveling off. The trend toward a somewhat lower concentration of foreign students in U.S. graduate programs is likely to continue, with fewer students from those places that are building their internal graduate S&E capacity, such as Taiwan and South Korea. The decline in foreign students from some Asian countries may be further exacerbated by the recent Asian economic crisis and the devaluation of currencies, making extended study abroad unaffordable.

The U.S. university system has accelerated the diffusion of S&E knowledge in the world through the education of foreign doctoral students, who have contributed both to the science and technology infrastructure in the United States and in their home countries. Many foreign doctoral recipients have remained in the United States for some time for further study or employment. As their home countries develop the need (and provide employment) for high-level skills, some of these foreign doctoral recipients return, bringing with them both their S&E education and U.S. work experience, further accelerating globalization of S&E. This improves other countries' economic competitiveness, as well as enhances the global good of improved scientific knowledge and world economic development. U.S. higher education is also enriched by the network of former doctoral students and faculty in key research centers in Asia and Europe. The benefits include enhanced cooperative research opportunities, expanded opportunities for U.S. graduate and undergraduate students to study abroad, and international postdoctoral research positions for young U.S. scientists and engineers.

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Science and Engineering Workforce

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Highlights

LABOR MARKET CONDITIONS

- **Overall labor market conditions were similar in 1993 and 1995, despite many changes in conditions for specific S&E fields.** Overall unemployment rates for science and engineering (S&E) Ph.D.-holders went from 1.6 percent to 1.5 percent. For recent Ph.D. recipients, the unemployment rate grew from 1.7 to 1.9 percent.
- **Only 2.4 percent of recent S&E Ph.D. recipients reported working in a non-S&E job that was unrelated to their field.** Based on the proportions reporting that they were involuntarily working outside of their field, the disciplines in which recent Ph.D. graduates found it most difficult to locate in-field employment in 1995 were political science (11.2 percent); mathematics (9.3 percent); sociology/anthropology (9.1 percent); earth, atmospheric, and oceanographic sciences (6.8 percent); and physics (6.7 percent). The biological sciences fared better, with 2.8 percent reporting involuntary outside-of-field employment; other measures, however, suggest a drop in the availability of tenure-track positions for recent biological sciences graduates.
- **Most holders of Ph.D.s in science and engineering do not work in academia.** Only 28.4 percent are employed as postsecondary teachers, and another 15.5 percent have some other employment at a four-year educational institution.
- **Only 12.1 percent of scientists and engineers in postdoctoral positions in 1993 were in tenure-track positions in 1995; 41.6 percent still held postdoctorate appointments.** Nevertheless, the length of time spent in postdoctoral positions appears to be only slightly greater than that reported retrospectively by those in mid-career.
- **While most individuals in postdoctorate positions in 1995 reported additional training and other customary reasons for accepting their appointments, 17.1 percent said that they had taken a postdoctorate because other employment was not available.** This proportion rises to 29.3 percent for the earth, atmospheric, and oceanographic sciences and to 26.8 percent for physics.

CHARACTERISTICS OF THE S&E WORKFORCE

- **Almost 3.2 million people with a bachelor's degree or higher were employed in an S&E occupation in 1995.** Engineers represented 42 percent (1.34 million) of all those in S&E occupations, followed by computer and math scientists with 30 percent (950,000) of the total. Physical scientists accounted for less than 10 percent of the S&E workforce in 1995.
- **The pattern of S&E degree production at each degree level over the last 50 years—rapid growth followed by a recent slowdown—creates a likely demographic pattern in the S&E labor force with several implications.** First, the number of scientists and engineers nearing traditional retirement ages will increase steadily and dramatically over the next 25 years. Second, even if there is no growth in the number of new S&E degree recipients, the size of the S&E-trained labor force will continue to increase for some time as the number of new entrants exceeds retirements and deaths. Finally, if degree production grows at a slower rate than in the past, the average age of scientists and engineers in the labor force will increase—with mixed implications for different aspects of research productivity.

INTERNATIONAL CONTEXT

- **A lower bound estimate of U.S. native-born S&E Ph.D. graduates living abroad is 13,900—3.3 percent of all such Ph.D. recipients.** If foreign-born doctoral recipients with U.S. citizenship or permanent residency at the time of their degrees are included, this figure rises to 19,600 (4.1 percent of the total).

PROJECTED DEMAND

- **During the 1996-2006 period, employment in S&E occupations is expected to increase at more than three times the rate for all occupations.** While the economy as a whole is anticipated to provide approximately 14 percent more jobs over this decade, employment opportunities for S&E jobs are expected to increase by about 44 percent or about 1.36 million jobs.

Introduction

Chapter Overview

Scientists and engineers play vital roles in the technological performance of U.S. industry in such areas as product or process innovation, quality control, and productivity enhancement. In addition, they conduct basic research to advance the understanding of nature, perform research and development (R&D) in a variety of areas such as health and national defense, train the nation's future scientists and engineers, and improve the scientific and technological literacy of the nation.

In the early 1990s, the U.S. science and engineering (S&E) workforce faced new and different challenges from those it experienced in the 1980s. A sluggish recession recovery, cutbacks in defense-related spending, reduced R&D budgets, and industry downsizing slowed the growth of S&E employment. Manufacturing S&E employment declined for the first time in more than a decade, while unemployment rates rose. Despite these trends, scientists and engineers have fared better than almost any other kind of worker. Moreover, the tight labor market has not precluded some S&E-trained individuals from finding meaningful, challenging work opportunities outside traditional S&E occupations.

Chapter Organization

This chapter first examines labor market conditions for recent bachelor's, master's, and doctoral S&E degree recipients. Information on the sex and racial/ethnic composition of the S&E workforce is next presented, followed by a description of S&E job trends in the service sector. The chapter provides data on foreign-born scientists and engineers, and presents comparisons regarding international R&D employment. It concludes with a brief section on the projected demand for S&E workers over the 1996-2006 decade.

Labor Market Conditions for Recent S&E Degree-Holders

Bachelor's and Master's Degree Recipients[1]

Recent S&E bachelor's and master's degree recipients are a key component of the nation's science and engineering workforce: they account for almost half of the annual inflow to the S&E labor market (NSF 1990, p. 40). The career choices of recent graduates and their entry into the labor market affect the balance between the supply of and demand for scientists and engineers in the United States. Analysis of the workforce status and other characteristics of recent S&E graduates can yield valuable labor market information. This section provides several labor market measures, including median annual salaries and in-field employment rates, that offer useful insights into the overall supply and demand conditions for recent S&E graduates in the United States.

Median Annual Salaries

In 1995, the highest median annual salaries of recent college graduates employed full time were earned by those with engineering degrees. The median annual salary for graduates with a bachelor's degree in engineering was $33,500; it was $44,000 for those with a master's degree. (See appendix table 3-1.) When compared with the salaries for recent science graduates with bachelor's degrees ($22,900) and master's degrees ($35,000), it is apparent that choice of a college major may significantly affect the salaries of recent college graduates entering the labor market.

School Versus Employment

About one out of four recent S&E bachelor's and master's degree recipients was enrolled in graduate school on a full-time basis in 1995. Students who had majored in the physical and life sciences were more likely to be going on to graduate school as full-time students than were those with degrees in mathematics and the computer sciences or engineering.

In-Field Employment

Success in the job market varies significantly by level and field of degree. One measure of success is the likelihood of finding employment directly related to a graduate's field of study. S&E master's degree recipients were more likely than bachelor's graduates to find work directly related to their field of study. Approximately one-half of all master's S&E degree recipients—but only a fifth of all S&E bachelor's recipients—were employed in their field of study in 1995. Among both master's and bachelor's degree recipients, students who had received their degrees in either engineering or the computer sciences were more likely to be working in their field of study. Students majoring in the social sciences were less likely to have jobs directly related to their degrees.

Employment Sectors

The private sector is by far the largest employer of recent bachelor's and master's degree recipients. In 1995, 59 percent of bachelor's degree recipients and 47 percent of master's degree recipients were employed in a private for-profit company. (See appendix table 3-2.) The academic sector is the second largest employer of recent S&E graduates. Master's degree recipients were more likely to be employed in four-year colleges and universities (23 percent) than were bachelor's degree recipients (13 percent). The federal sector employs only 7 percent of S&E master's degree recipients and 4 percent of S&E bachelor's degree recipients. Engineering graduates are more likely than science graduates to find employment in the federal sector. Sectors employing smaller numbers of recent

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[1] Data in this section are taken from the 1995 National Survey of Recent College Graduates. This survey collected information on the 1995 workforce/other status of 1993 and 1994 bachelor's and master's degree recipients in S&E fields. Surveys of recent S&E graduates have been conducted biennially for the National Science Foundation since 1978. For information on standard errors associated with survey data, see NSF (1997b).

S&E graduates include educational institutions other than four-year colleges and universities, private nonprofit organizations, and state or local government agencies.

Doctoral Degree Recipients

Concerns have been raised about labor market opportunities for new Ph.D. scientists and the possible consequences on the health of scientific research in the United States.[2] Several recent developments have contributed to these concerns, including demographic changes (which have slowed the growth in undergraduate enrollment), reductions in defense and research funding, growth in the importance of Ph.D. programs at foreign schools (see chapter 2, "Worldwide Increase in S&E Educational Capabilities"), and rates of Ph.D. production that approach or exceed the high levels realized at the end of the Vietnam draft.

Since the 1950s, the Federal Government has actively encouraged graduate training in science through a number of mechanisms. However, widespread unemployment or involuntary movement out of S&E by large numbers of new Ph.D. scientists and engineers could have various adverse effects on the health of scientific research in the United States. If labor market difficulties are real but temporary, promising students may be discouraged from pursuing degrees in S&E fields. Eventually, this circumstance could reduce the ability of industry, academia, and government to perform R&D. If labor market difficulties are long term, restructuring will need to take place within graduate education and federal research support to maintain quality research. In either case, when much high-level human capital goes unused, society loses potential opportunities for new knowledge and economic advancement—and individuals feel frustrated in their careers.

Aggregate measures of labor market conditions for recent Ph.D. recipients (one to three years since degree) changed only slightly between April 1993 and April 1995.[3] The unemployment rate for all recent Ph.D. recipients rose from 1.7 percent in 1993 to 1.9 percent in 1995. (See text table 3-1.) The rate of recent Ph.D.s involuntarily working outside of their degree fields rose slightly, from 4.0 percent in 1993 to 4.3 percent in 1995. These aggregate numbers mask much larger changes in labor market conditions—both positive and negative—within individual disciplines.

Most individuals who complete an S&E doctorate are looking for more than just steady employment at a good salary. Their technical and problem-solving skills make them highly employable, but the opportunity to do the type of work they want and for which they have been trained is important to them. For that reason, no single measure can well describe the S&E labor market. Some of the available labor market indicators are discussed below.

Unemployment Rates

Only 1.9 percent of recent (one to three years after degree award) Ph.D. recipients were unemployed in April 1995.[4] (See text table 3-1.) This number is low compared to the 5.7 percent unemployment rate for all civilian workers, and is only slightly higher than the 1.5 percent rate for S&E doctoral recipients. In several fields, however, new Ph.D.s faced higher unemployment rates: 4.3 percent in chemical engineering, 4.0 percent in mathematics, 3.2 percent in sociology/anthropology, and 2.9 percent in physics. While still much lower than for the general population, these unemployment rates are unusually high for a highly skilled group. For recent physics Ph.D.s, however, the 2.9 percent rate represents a large drop from the 5.3 percent unemployment rate reported by the 1993

Text table 3-1.
Labor market rates for recent Ph.D.s, by degree field
(Percentages)

	Unemployed		Involuntary out-of-field employment	
Ph.D. degree field	1993	1995	1993	1995
All S&E	1.7	1.9	4.0	4.3
Life sciences	0.9	2.0	2.6	2.6
Agricultural sciences	1.1	1.1	2.7	2.2
Biological sciences	0.7	2.2	2.3	2.8
Health/medical sciences	1.5	1.3	2.1	2.2
Math and computer sciences	1.1	2.6	4.9	6.2
Mathematics	0.7	4.0	7.1	9.3
Computer sciences	1.5	1.1	2.1	2.7
Physical sciences	3.0	2.4	5.4	5.3
Chemistry	1.6	2.1	4.0	4.1
Earth, atmospheric & oceanographic	3.4	1.7	8.5	6.8
Physics	5.3	2.9	6.1	6.7
Social sciences	1.8	1.4	4.6	5.5
Economics	2.1	1.4	4.1	2.7
Political science	2.4	2.5	5.1	11.2
Psychology	1.4	0.5	2.2	3.8
Sociology/anthropology	3.3	3.2	11.6	9.1
Engineering	1.9	1.7	3.7	3.7
Chemical	1.1	4.3	2.1	3.3
Civil	1.9	1.3	1.4	1.0
Electrical	1.9	0.9	3.8	3.0
Mechanical	1.3	2.8	8.3	5.0

NOTE: Recent Ph.D.s are those who received their degrees one to three years previously.

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Doctorate Recipients, merged 1993 and 1995 files.

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cohort. On the other hand, the rates for mathematics and chemical engineering are notably greater than the negligible 0.7 and 1.1 percent rates reported respectively in 1993.

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[2] For a more detailed discussion, see COSEPUP (1995).

[3] This section primarily uses data from the 1993 and 1995 Survey of Doctorate Recipients (SDR), a biennial National Science Foundation (NSF) survey of doctorate-holders from U.S. institutions up to age 75; and the closely related Scientists and Engineers Statistics Data System (SESTAT) integrated file which contains data from the SDR and two other NSF surveys, the National Survey of College Graduates and the National Survey of Recent College Graduates. For more informaiton on SDR, see chapter 5, "Data Sources: Nature, Problems, and Comparability."

[4] People are said to be unemployed if they were not employed during the week of April 15, 1995, and had either looked for work during the preceding four weeks or were on layoff from a job.

Involuntarily Working Outside of Field

Another 4.3 percent of recent S&E Ph.D. recipients in the labor force reported that they could not find full-time employment "closely related" or "somewhat related" to their degrees. These persons are considered to be IOF—involuntarily out-of-field. This definition of IOF includes those working part time in their fields because full-time work was not available.

As with unemployment, IOF rates varied greatly by field, with 11.2 percent in political science; 9.3 percent in mathematics; 9.1 percent in sociology anthropology; 6.8 percent in earth, atmospheric, and oceanographic sciences; and 6.7 percent in physics. (See text table 3-1.) Fields with relatively low IOF rates for recent Ph.D.s included 1.0 percent in civil engineering, 2.2 percent for both agricultural and medical sciences, 2.7 percent for both economics and computer sciences, and 2.8 percent in the biological sciences.

Tenure-Track Positions

Most S&E Ph.D. recipients do not work in academia. (See "How Traditional Is an Academic Career?"; but also see chapter 5, "The Academic Doctoral S&E Workforce.") Across all fields and ages, only 30.8 percent of S&E Ph.D.s in the labor force are in tenure-track or tenured positions at four-year educational institutions. (See text table 3-2.) Across fields, academic tenure-track employment varies from a high of 54.0 percent for economics to a low of 14.0 percent for chemical engineering. Still, the availability of tenure-track positions is an important aspect of the job market for those who do seek academic careers.

In 1995, 15.9 percent of recent S&E Ph.D. recipients were in tenure-track positions. (See text table 3-2.) This proportion rose to 26.8 percent among those who had received their doctorates within the previous four to six years; it was greater still (30.5 percent) for those at mid-career—11 to 20 years after degree. The percentage of Ph.D.s with tenure-track positions does not, however, reveal much about how difficult it is to obtain academic employment—in fields where many new Ph.D.s prefer employment in industry, there may actually be less competition for academic jobs.

Comparable historical data on tenure-track rates in early career are not available, but comparisons with mid-career tenure-track rates do provide an imperfect indicator of changes in the availability of academic positions. By this relative measure, early career tenure-track rates (four to six years out) are noticeably lower in the biological sciences (–14.4 percentage points), agriculture (–10.1), chemical engineering (–8.6), and physics (–4.7).

The differences in tenure-track rates in the biological sciences are a notable part of a complicated labor market profile for that field. Both unemployment and IOF rates are relatively low in the biological sciences. However, salaries are also lower—and, evidently, so are the opportunities for tenure-track academic employment.

Relationship Between 1995 Occupation and Degree Field

By a strict definition of occupational titles, 31.5 percent of employed recent Ph.D.s were in occupations outside science and engineering, often with administrative or management functions. When asked how related their jobs were to their highest degree, only a small proportion of recent Ph.D.s in non-S&E occupations said that their jobs were unrelated to their degree. (See text table 3-4.) By field, these respondents ranged from 1.5 percent of recent engineering Ph.D. graduates to 4.5 percent of recent Ph.D. graduates in mathematics and the computer sciences.

Changes in Employment Status

Of the 72.2 percent of recent S&E Ph.D. recipients who were in "regular" employment in 1993 (that is, not in a postdoctorate appointment and not involuntarily working outside of their fields), the vast majority—94 percent—were still in regular employment in 1995. (See figure 3-1.) Of those in other 1993 employment statuses (postdoctorate, IOF, or unemployed), 50 percent of each group had moved to regular employment by 1995. Forty-five percent of 1993

Text table 3-2.
Scientists and engineers holding tenure and tenure-track appointments at four-year institutions, by degree field and years since Ph.D. award: 1995
(Percentages)

	Early career		Mid-career	
Ph.D. degree field	1-3 years	4-6 years	11-20 years	All years
All S&E	15.9	26.8	30.5	30.8
Agricultural sciences	13.4	26.0	36.1	32.8
Biological sciences	8.8	19.8	34.2	32.5
Health/medical sciences	32.5	45.2	37.9	39.0
Mathematics	36.0	52.7	51.3	53.5
Computer sciences	34.5	42.3	38.9	40.9
Chemistry	6.9	14.6	15.1	18.8
Earth, atmospheric & oceanographic sciences	10.9	30.1	27.3	28.8
Physics	5.8	15.6	20.3	23.5
Economics	42.4	55.4	52.2	54.0
Political science	29.5	68.4	51.6	52.7
Psychology	13.1	19.8	19.8	22.1
Sociology/anthropology	32.2	50.4	49.2	49.9
Chemical engineering	6.6	6.0	14.6	14.0
Civil engineering	25.5	29.9	33.7	34.5
Electrical engineering	10.8	22.5	26.4	22.9
Mechanical engineering	14.4	26.3	24.2	23.3

SOURCE: National Science Foundation, Science Resources Division, 1995 Survey of Doctorate Recipients.

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How Traditional Is an Academic Career?

It has long been known from the Survey of Doctorate Recipients (SDR) and other labor force surveys that a large majority of doctorate level scientists and engineers, at any one point in time, work outside academia. The 1995 Scientists and Engineers Statistics Data System (SESTAT) Work History Module, combined with the 1995 SDR core questions, provides current and retrospective career information that allows mapping of typical career paths.

Text table 3-3 divides the population of employed S&E doctorate-holders into four groups: those currently employed as postsecondary teachers, those currently in nonteaching jobs at four-year institutions, those who were formerly postsecondary teachers at some time after completion of their Ph.D.s, and those not currently employed in academia and who reported no postsecondary teaching positions since completion of their Ph.D.s. (Note that tenured administrators and other nonteaching faculty make up most of the difference between the percentage in postsecondary teaching positions and those with tenure or in tenure-track positions; also note that many nonteachers employed in academia also report being former postsecondary teachers.) One weakness of this analysis based on occupation is that it does not capture the past academic affiliations of scientists and engineers who are hired as administrators or researchers without ever being part of the teaching faculty.

Text table 3-3.
Current or former employment of S&E Ph.D.s as postsecondary teachers, by field: 1995
(Percentages)

Ph.D. degree field	Current post-secondary teacher	Current nonteaching employment at 4-year institution	Former post-secondary teacher	Never post-secondary teacher
All S&E	28.4	15.5	9.4	46.7
Life sciences	25.7	23.8	6.9	43.6
Math and computer sciences	48.5	9.4	11.7	30.4
Physical sciences	22.6	14.6	8.5	54.3
Social sciences	35.6	11.6	12.6	40.1
Engineering	20.3	10.9	8.4	60.4

NOTE: Data are for those employed as of April 1995.

SOURCE: National Science Foundation, Science Resources Studies Division, 1995 SESTAT (Scientists and Engineers Statistics Data System), Work History Module. *Science & Engineering Indicators – 1998*

A small majority—53.3 percent—of employed S&E doctorate-holders in 1995 were either currently in academia or reported past employment as postsecondary teachers since receiving their degrees. There is less academic involvement in engineering and the physical sciences, where majorities report never having been employed as postsecondary teachers or having no current employment in academia. It is also noteworthy that even in mathematics and the computer sciences, where employment in academia is heaviest, a large majority of currently nonacademic scientists and engineers appears never to have held academic teaching jobs. This view is consistent with shorter career views obtained by longitudinal matching of the SDR data; these data show relatively little movement between academia and industry, excluding new graduates and postdoctorates.

Text table 3-4.
Comparison of degree field and occupation field for recent S&E Ph.D.s: 1995
(Percentages)

Ph.D. degree field	Occupation field: Same as degree	Other S&E	Related non-S&E	Unrelated non-S&E
All S&E	61.5	7.0	29.1	2.4
Life sciences	58.0	4.6	35.6	1.8
Math and computer sciences	65.1	3.6	26.8	4.5
Physical sciences	59.8	10.3	27.4	2.5
Social sciences	69.5	4.2	23.1	3.2
Engineering	55.9	12.0	30.6	1.5

NOTE: Recent Ph.D.s are those who received their degrees one to three years previously.

SOURCE: National Science Foundation, Science Resources Studies Division, 1995 Survey of Doctorate Recipients.

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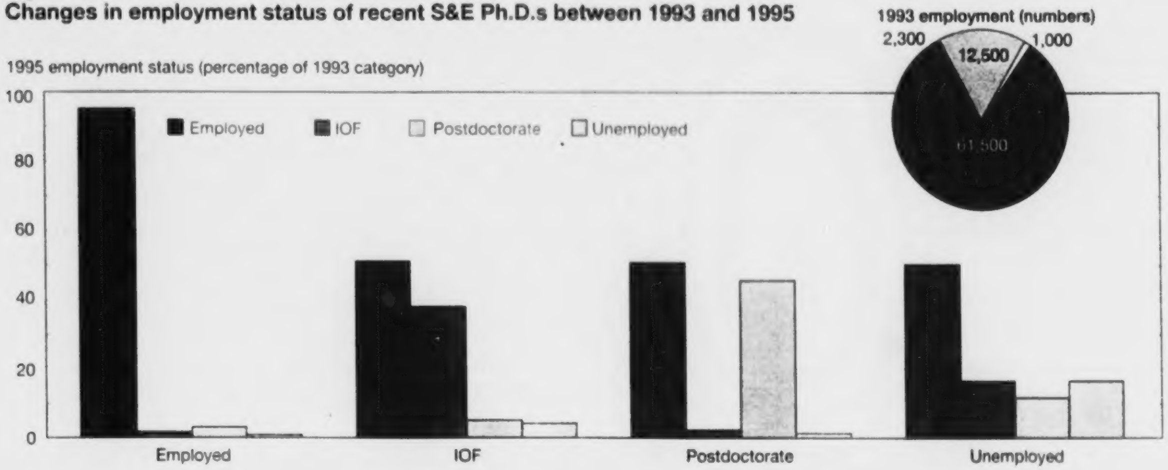
postdoctorates were still in a postdoctorate position in 1995; 37 percent of those working involuntarily outside of their fields were IOF in 1995 as well. There was, however, much less evidence of long-term unemployment: only 0.3 percent were unemployed in both 1993 and 1995.

Median Annual Salaries

The median salary earned by recent science and engineering Ph.D. recipients in 1995 was $40,000, with the highest median found for engineering Ph.D.s ($54,000) and the lowest for Ph.D.s in the life sciences ($32,000). Despite the wide variety of employment types and fields for new Ph.D. recipients, there is a fairly narrow distribution of salaries around this median—the 10th percentile makes $22,500 and the 90th percentile, $65,000. (See text table 3-5.) The lowest 10th percentile salary ($8,000) is found for recent Ph.D. recipients in sociology/anthropology. The highest 90th percentile salary was $85,000, for recent Ph.D. recipients in the computer sciences and economics.

Figure 3-1.
Changes in employment status of recent S&E Ph.D.s between 1993 and 1995



NOTES: Recent Ph.D.s are those who received their degrees between 1990 and 1992. IOF is involuntarily out of field.

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Doctorate Recipients, merged 1993 and 1995 files.

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Text table 3-5.
Salary distribution for recent S&E Ph.D.s, by degree field: 1995
(Dollars)

	Percentile				
Ph.D. degree field	10th	25th	Median	75th	90th
All S&E	22,500	30,000	40,000	54,400	65,000
Life sciences	22,000	26,000	32,000	43,500	58,000
Agricultural sciences	24,000	26,500	37,949	47,900	55,000
Biological sciences	21,000	25,000	30,000	37,000	52,000
Health/medical sciences	25,000	35,480	45,000	55,000	65,000
Math and computer sciences	28,500	35,000	45,000	60,000	75,000
Mathematics	25,000	32,000	36,000	47,000	64,000
Computer sciences	40,000	44,500	55,000	70,000	85,000
Physical sciences	22,000	30,000	38,000	52,000	61,000
Chemistry	20,000	27,000	42,000	55,000	62,000
Earth, atmospheric & oceanographic	25,000	32,000	37,000	46,000	60,000
Physics	24,000	30,000	36,000	50,000	60,000
Social sciences	19,600	30,000	38,000	49,850	67,933
Economics	36,000	42,000	48,000	60,000	85,000
Political science	25,000	32,000	37,000	50,500	71,600
Psychology	18,500	28,000	37,500	48,500	67,000
Sociology/anthropology	8,000	25,600	33,000	40,000	52,700
Engineering	32,000	43,000	54,000	63,000	72,000
Chemical	31,000	46,000	58,200	65,000	68,000
Civil	35,000	43,000	48,000	55,400	66,600
Electrical	38,000	50,000	60,000	68,000	79,600
Mechanical	36,000	45,000	52,000	60,000	67,000

NOTE: Recent Ph.D.s are those who received their degrees one to three years previously.

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Another meaningful way to view new doctorate salaries is by sector of employment. Median salaries in 1995 for recent Ph.D.s were highest in the private, noneducation sector ($56,000) and lowest for postdoctorates ($28,000). (See text table 3-6.) Government salaries tended to be just slightly above those of tenure-track positions in academia.[5] While the pattern of salary by degree field also varied by sector of employment, salaries were generally higher in engineering and math/computer sciences and lower in the social and life sciences.

Postdoctorate Appointments

A postdoctoral appointment is defined here as a temporary position awarded in academia, industry, or government primarily for the purpose of gaining additional training in research. This definition is used in the 1995 Survey of Doctorate Recipients to ask respondents about current and past postdoctorate positions they have held.[6]

Data and analyses on postdoctorates are closely related to recent Ph.D. labor market issues. In addition to gaining more training, recent Ph.D. recipients may accept a temporary, usually lower paying, postdoctorate position because a more permanent job in their field is not available. NSB (1996) reported that there was no strong evidence that the number or length of postdoctorate positions was being driven by changes in labor market conditions. With the new data provided by an extensive postdoctorate module in the 1995 Survey of Doctorate Recipients, some labor market effects can now be discerned in some specific disciplines.

Reasons for Taking a Postdoctorate. The most commonly reported reason given by 1995 postdoctorates for taking a postdoctorate appointment was to acquire additional training in their Ph.D. field (35.4 percent).[7] Other respondents reported that they were taking a postdoctorate to receive training outside of their respective Ph.D. field[8] (18.5 percent) or to work with a particular researcher or institution (21.5 percent). Text table 3-7 shows reported reasons for taking a postdoctorate in the six fields that accounted for 92 percent of 1995 S&E postdoctorate appointments.

Beyond these traditional uses of a postdoctorate, 17.1 percent of respondents reported that they accepted a postdoctorate appointment because other employment was not available. This proportion rises to 29.3 percent in the earth, atmospheric, and oceanographic sciences and to 26.8 percent in physics—two fields with relatively high unemployment and IOF rates among recent Ph.D. graduates.

Incidence and Length of Postdoctorate Appointments. Although there are some postdoctorate positions in all academic disciplines, most are concentrated in a small number of fields in which postdoctorate appointments are part of a traditional career path. Although some scientists and engineers appear to take postdoctorate positions at all points in their careers, they usually do so within a few years of completing their doctorate. (See figure 3-2.) The incidence of postdoctorate appointments is greatest in the biological sciences and physics, but few are in postdoctorate positions in these fields beyond six years after degree award.[9]

Text table 3-8 provides information from the SDR Postdoctorate Module on the proportion of each graduation cohort that ever held a postdoctorate position and the median

Text table 3-6.
Salaries of recent S&E Ph.D.s, by degree field and employment sector: 1995
(Dollars)

Ph.D. degree field	Private, noneducational	Government	Tenure track	Postdoctorate	Other education
All S&E	56,000	46,000	41,300	28,000	35,000
Life sciences	52,000	42,500	42,500	26,500	33,900
Math and computer sciences	65,000	61,250	43,000	35,000	35,900
Physical sciences	55,000	52,000	38,000	30,000	34,000
Social sciences	48,000	44,784	38,200	27,000	34,000
Engineering	60,000	52,000	49,300	33,000	43,000

SOURCE: National Science Foundation, Science Resources Studies Division, 1995 Survey of Doctorate Recipients.

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[5] Salaries reported on an "academic year" basis have not been adjusted upwards, as was done in pre-1996 volumes of *Science & Engineering Indicators*.

[6] It is clear, however, that the exact use of the term "postdoctorate" differs among academic disciplines, among different universities, and among the different sectors that employ postdoctorates. It is likely that these differences in labeling affected self-reporting of postdoctorate status on the Survey of Doctorate Recipients.

[7] A recent joint National Science Foundation-French National Center for Scientific Research (CNRS) project to study French doctorates and postdoctorates in the United States showed a similar pattern. Although not a fully representative sample, many of the respondents noted that the reason they took a postdoctorate in the United States was to improve their job opportunities in France (see Terouanne 1997).

[8] Many respondents to this question may have interpreted "field" very narrowly, so training outside of their field may simply refer to a subfield of their discipline that lies outside their dissertation work.

[9] The profile of those who had a postdoctorate in 1995 does not reveal much about the length of time spent in postdoctoral appointments—a person in a postdoctorate six years after obtaining a Ph.D. may have just begun the appointment. The profile also does not reveal much about how postdoctorates today differ from their historical patterns.

Text table 3-7.
Reasons for taking current postdoctorate, by field: 1995
(Percentages)

Ph.D. degree field	Additional training in Ph.D. field	Training outside of Ph.D. field	Work with a particular person or place	Other employment not available	Other
All S&E	35.4	18.5	21.5	17.1	7.5
Agricultural sciences	38.1	13.7	11.8	20.6	15.8
Biological sciences	38.6	23.2	20.9	11.1	6.3
Chemistry	26.3	13.0	18.4	21.8	10.4
Earth, atmospheric & oceanographic sciences	25.2	3.4	38.7	29.3	3.4
Physics	33.1	12.1	21.6	26.8	6.5
Psychology	43.0	11.5	21.7	13.1	10.8

SOURCE: National Science Foundation, Science Resources Studies Division, 1995 Survey of Doctorate Recipients, Postdoctorate Module.

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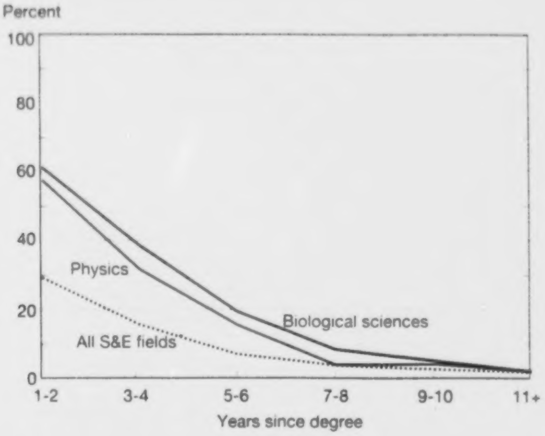
Figure 3-2.
Percentage of Ph.D.s in postdoctorate positions, by years since degree: 1995



SOURCE: National Science Foundation, Science Resources Studies Division, 1995 Survey of Doctorate Recipients.

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Text table 3-8.
Incidence and length of postdoctorate appointments, by selected S&E fields: 1995

Field	Years since Ph.D. degree 1-3	4-6	7-10	11-20	21-30	31+
Percentage ever in postdoctorate appointment						
All S&E	41.3	37.9	36.3	34.0	29.2	25.0
Agricultural sciences	43.9	43.9	35.0	27.6	19.2	14.0
Biological sciences	71.0	71.5	71.8	66.3	51.2	39.9
Chemistry	63.0	57.7	55.2	46.1	50.6	30.5
Earth, atm. & ocean. sciences	48.5	52.3	40.0	37.3	21.4	15.3
Physics	72.9	68.1	59.0	52.7	44.4	29.3
Psychology	31.8	23.6	27.3	25.3	21.3	22.5
Months spent in postdoctorate appointment						
All S&E	18	29	29	26	23	20
Agricultural sciences	20	20	22	25	25	12
Biological sciences	23	46	45	38	28	24
Chemistry	19	22	24	22	23	16
Earth, atm. & ocean. sciences	17	23	19	16	12	14
Physics	23	34	32	25	24	23
Psychology	12	15	16	20	13	19

NOTES: Fields selected are those with a high incidence of postdoctorate appointments. "Months spent in postdoctorate appointment" refers to the median of the sum of the lengths of each reported postdoctorate experience.

SOURCE: National Science Foundation, Science Resources Studies Division, 1995 Survey of Doctorate Recipients, Postdoctorate Module.

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number of months in postdoctorates for those who held them.[10] For the more recent cohorts, particularly those only one to three years since degree, length of time in postdoctorate is constrained by the limited time they have held their degrees.

Across all fields, the Postdoctorate Module shows a steady increase over time in both the incidence and length of postdoctorate experiences. It is difficult to tie these trends directly to labor market events or even to claim a consistent pattern across fields. In physics, chemistry, and psychology—fields with distinct labor markets—the incidence of postdoctorates between one to three and four to six years after degree has risen, despite the lesser opportunity of the younger cohort to obtain a postdoctorate. In psychology, the agricultural sciences, and chemistry, there is no trend toward longer postdoctorate appointments. In the biological sciences, even the mid-career cohort—11 to 20 years after degree—had a very high incidence (66.3 percent) and length (38 months) of postdoctorate positions.

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[10] Recall bias may well lead to underreporting of postdoctorate experiences by older cohorts, but this occurrence may be less problematic than comparisons of reported postdoctorate rates among the sometimes dissimilar survey instruments used over the years. For length of appointment, up to three postdoctorates reported in the Postdoctorate Module are aggregated.

Postdoctorate Transitions: What Were 1993 Postdoctorates Doing in 1995? Of those in postdoctorate positions in April 1993, 41.6 percent were still in a postdoctorate position in April 1995. (See text table 3-9.) Only 12.1 percent transitioned from a postdoctorate to a tenure-track position at a four-year educational institution; 21.2 percent found other positions at educational institutions, and 16.6 percent went to work for a private for-profit firm.

The percentage of postdoctorates obtaining tenure-track positions is not large even for those with greater time since degree—only 18.8 percent of 1993 postdoctorates who were five to six years since degree were in tenure-track positions in 1995. (See text table 3-10.) This is, however, a much greater rate of transition to permanent academic jobs than for postdoctorates one to two years since degree (10.4 percent). One in five is still a low rate if an academic career is viewed as the primary objective of most Ph.D. scientists accepting a postdoctorate appointment at that point in their career.

For those in postdoctorates seven or more years after their degree, the rate of transition to tenure-track appointments drops to 9.8 percent. To a great extent, this rate is driven by career patterns in the biological sciences, where there have long been large numbers of Ph.D. scientists pursuing multiple postdoctorate appointments. However, in physics—where multiple postdoctorates are a more recent phenomenon[11]—the percentage of postdoctorates transitioning to tenure-track appointments begins to drop much earlier (three to four years since degree), to 7.1 percent.

For both physics and the biological sciences, the unemployment rate in 1995 for 1993 postdoctorates was greatest for those with more time since degree—3.4 percent for biological scientists seven or more years since degree and for physicists three to four years after degree. There was also an increase in the rate of transition to the "other education" category. This category includes some individuals who become adjunct faculty, but it primarily encompasses other non-tenure-track research and administrative jobs at a university.

Selected Characteristics of the S&E Workforce

The data in this section are drawn from the National Science Foundation's (NSF's) Scientists and Engineers Statistical Data System (SESTAT),[12] which is a unified database containing information on the employment, education, and other characteristics of the nation's scientists and engineers. For a discussion of labor force indicators drawn from other surveys, see "The S&E Labor Market Since 1995: Indicators From Other Surveys."

Basic Characteristics

Of the approximately 3.3 million individuals in science and engineering occupations in the labor force in 1995, only 2.2 percent (70,600) reported themselves as unemployed. The highest unemployment rate was reported for physical

Text table 3-9.
Employment status of 1993 postdoctorates, by S&E field: 1995
(Percentages)

Field	Post-doctorate	Tenure track at 4-year institution	Other education	Private for-profit	Private not-for-profit/ government	Unemployed
All S&E	41.6	12.1	21.1	16.6	6.9	1.6
Agricultural sciences	47.5	5.8	18.9	15.8	6.7	5.4
Biological sciences	47.8	12.0	20.5	12.9	4.9	1.9
Chemistry	35.2	13.2	12.5	32.0	6.4	0.9
Earth, atmospheric & oceanographic sciences	34.0	12.6	33.2	7.8	12.5	0.0
Physics	43.0	12.7	20.9	14.7	6.2	2.6
Psychology	34.4	11.3	28.2	15.1	11.0	0.0

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Doctorate Recipients, merged 1993 and 1995 files.

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[11] See text table 3-8 for the historical pattern of postdoctorates. Due to the small numbers of physicists in postdoctorates beyond four years after their degree, there was not a sufficient sample size to estimate transition rates.

[12] SESTAT data are collected from three component surveys sponsored by NSF and conducted periodically throughout each decade: (1) the National Survey of College Graduates, (2) the National Survey of Recent College Graduates, and (3) the Survey of Doctorate Recipients. SESTAT's target population is residents of the United States with a bachelor's degree or higher (in either an S&E or non-S&E field) who, as of the study's reference period, were:

- ◆ non-institutionalized,
- ◆ not older than age 75, and
- ◆ either trained or working as a scientist or engineer—i.e., either had at least one bachelor's or higher degree in an S&E field or had a bachelor's or higher degree in a non-S&E field and worked in an S&E occupation as of the reference week.

For the 1995 SESTAT, the reference period was the week of April 15, 1995.

Text table 3-10.
Postdoctorate transitions by years since 1993 degree: 1995
(Percentages)

Postdoctorate field and years since 1993 degree	1995 employment status of 1993 postdoctorates					
	Tenure track	Post-doctorate	Other education	Non-education	IOF	Unemployed
All S&E	11.9	40.5	20.2	21.4	3.1	1.6
1-2 years	10.4	45.8	16.2	22.2	3.3	1.0
3-4 years	13.4	36.5	21.9	21.3	2.3	2.7
5-6 years	18.4	35.8	18.6	18.7	3.7	2.5
7 or more years	9.8	28.4	33.1	20.2	3.9	1.7
Biological sciences	11.6	46.5	19.2	15.8	2.8	1.9
1-2 years	6.3	58.8	15.6	14.1	3.1	0.7
3-4 years	16.5	38.0	19.5	19.1	1.6	2.9
5-6 years	20.1	35.6	18.2	16.2	3.7	2.5
7 or more years	13.4	27.9	34.2	14.2	4.1	3.4
Physics	12.5	42.3	20.6	17.6	3.3	2.6
1-2 years	14.0	47.5	13.5	16.8	5.9	1.9
3-4 years	7.1	35.8	35.2	15.5	0.0	3.4
5-6 years	n/s	n/s	n/s	n/s	n/s	n/s
7 or more years	n/s	n/s	n/s	n/s	n/s	n/s

n/s = not surveyed

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Doctorate Recipients, merged 1993 and 1995 files.

NOTE: Some percentages may differ from those in text table 3-9 due to the inclusion of involuntarily out-of-field (IOF) employment.

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The S&E Labor Market Since 1995: Indicators From Other Surveys

Although detailed biennial surveys of individuals such as NSF's SESTAT allow examination of complex patterns and long-term trends in education and employment, they are less well-suited to tracking short-term changes in employment rates. Data from the 1997 NSF labor force surveys are still in the process of being collected, but other data may serve as indicators of changes in market conditions since April 1995. In general, these data suggest that labor market conditions are improving. This is consistent with improvements in the general economy, specifically with unemployment rates for all workers, as measured by the monthly Current Population Survey, which dropped from 5.7 percent in April 1995 to 4.7 percent in October 1997. Thus:

- The American Mathematical Society surveyed 1996-97 new recipients of mathematics Ph.D.s in the fall of 1997. This soon after graduation, the unemployment rate was a relatively high 6.8 percent. However, this rate represents a large decrease from the 14.7 percent unemployment rate found for the 1994-95 Ph.D. cohort two years earlier by the same survey.
- The American Institute of Physics estimated a 4.0 percent unemployment rate for the 1994-95 cohort of recipients of physics Ph.D.s in the winter after their degrees. The corresponding estimate of the previous year, for the 1993-94 cohort, was 5.0 percent unemployment.
- In 1997, several S&E professional societies, in collaboration with the Commission on Professionals in Science and Technology, coordinated their surveys of new Ph.D.s. Among other common survey items, recent Ph.D. recipients were asked to characterize on a scale of 1 to 5 (where 1 is strongly disagree and 5 is strongly agree) their agreement with various statements about their current jobs. Preliminary results are available for chemistry, chemical engineering, computer sciences, earth and space sciences, and psychology. New Ph.D.s in these fields showed much agreement that their current jobs were "at least somewhat related to my field" (average values within a field ranged from 4.3 for chemical engineering to 4.6 for the computer sciences); and that the job was "commensurate with my education and training" (mean scores of 4.1 to 4.4). However, there was less agreement with "position similar to what I expected to be doing when I began my doctoral program," with mean values ranging from 3.4 in psychology to 3.7 in the computer sciences.

scientists (2.7 percent) and the lowest for social scientists (1.2 percent). By degree level, only 2.1 percent of the scientists and engineers whose highest degree was a bachelor's degree and 1.8 percent of those with a doctorate were unemployed, compared to 2.5 percent of those with a master's degree. (See figure 3-3.)

Employment by Field

Engineers represented 42 percent (1.34 million) of the employed scientists and engineers in 1995; followed by computer and math scientists, who accounted for 30 percent (950,000) of the total. (See appendix table 3-4.) Physical scientists accounted for less than 10 percent of the S&E workforce in 1995. By subfield, electrical engineers made up about one-fourth (357,000) of all employed engineers, while biological scientists accounted for a little over half (169,000) of the employment in the life sciences. In physical and social science occupations, chemists (111,000) and psychologists (167,000) made up the largest occupational subfields, respectively.

Highest Degree Level

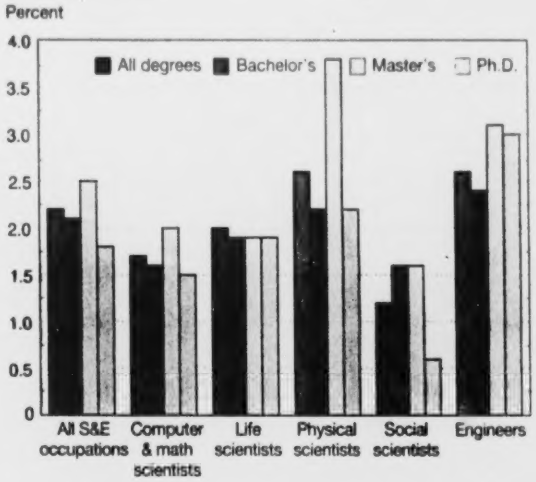
Almost 58 percent of those working in S&E occupations in 1995 reported their highest degree as a baccalaureate, while 28 percent listed a master's degree and 13 percent a doctorate. (See appendix table 3-4.) Other professional degrees were reported as the highest degree type achieved by about 1 percent of the S&E workforce. Almost half of those with bachelor's degrees were employed as engineers. (See text table 3-11.) Another 34 percent had jobs as computer and math scientists. These occupations were also the most popular among those with master's degrees (40 percent and 30 percent, respectively). Most doctorate-holders were employed in the social sciences (27 percent), life sciences (25 percent), and physical sciences (19 percent).

Relationship Between Occupation and Education

Approximately 83 percent (2.6 million) of those in the S&E workforce in 1995 had their highest degree in an S&E field; the exact proportions vary by highest degree level. About 74 percent of master's degrees were in an S&E field, compared to 94 percent of doctoral degrees (NSF 1995c). By field, almost 77 percent of engineers and 80 percent of social scientists were working in their highest degree fields. Similar proportions existed among physical scientists (73 percent) and life scientists (71 percent). By contrast, over 57 percent of computer and math scientists reported their highest degrees to be in other fields. (See text table 3-12.)

A large number of people trained in S&E disciplines routinely find S&E-related employment in nontraditional S&E occupations. For example, approximately 4.7 million people with S&E degrees were employed in non-S&E occupations in 1995; about 65 percent of these reported that their work was at least somewhat related to their degrees. (See text table 3-13.) Approximately four-fifths of both doctoral and master's S&E de-

Figure 3-3.
Unemployment rates of scientists and engineers, by broad occupation and highest degree received: 1995



NOTE: Total includes other professional degree recipients.

See appendix table 3-3. *Science & Engineering Indicators – 1998*

Text table 3-11.
Distribution of employed scientists and engineers, by broad occupation and highest degree received: 1995
(Percentages)

Occupation	Total	Bachelor's degree	Master's degree	Ph.D. degree	Other professional degree
All scientists and engineers	100.0	100.0	100.0	100.0	100.0
Computer and math scientists	29.8	33.9	30.0	12.9	8.8
Life scientists	9.6	6.6	7.2	24.5	56.7
Physical scientists	8.6	6.9	7.5	18.9	0.6
Social scientists	10.0	3.3	15.2	27.1	25.8
Engineers	42.0	49.3	40.1	16.7	8.1

See appendix table 3-4. *Science & Engineering Indicators – 1998*

Text table 3-12.
Distribution of employed scientists and engineers, by broad occupation and degree field: 1995
(Percentages)

		Degree field (all levels)					
Occupation	Total	Math & computer sciences	Life sciences	Physical sciences	Social sciences	Engineering	Non-S&E
All scientists and engineers	100.0	14.0	9.3	9.8	12.1	37.5	17.3
Computer and math scientists	100.0	42.8	2.3	3.9	9.3	15.3	26.3
Life scientists	100.0	0.5	71.1	6.4	4.7	1.2	16.1
Physical scientists	100.0	1.8	12.2	73.2	2.7	5.2	5.0
Social scientists	100.0	0.5	1.1	0.3	79.7	0.5	17.8
Engineers	100.0	2.4	1.6	4.1	1.6	76.8	13.6

See appendix table 3-5.

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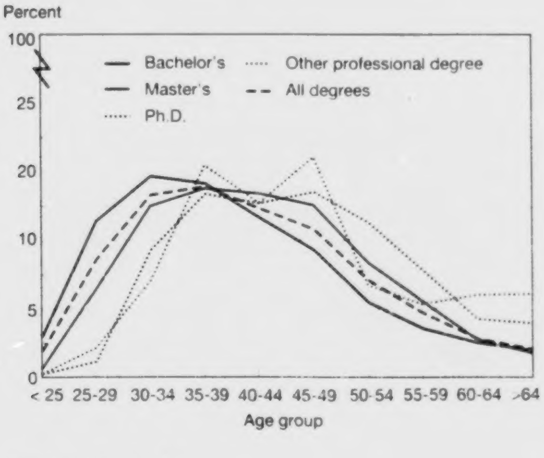
gree recipients who were employed in non-S&E occupations in 1995 reported that their jobs were closely related to their degrees, compared to three-fifths of bachelor's degree-holders.

Age Distribution

Age distributions for S&E occupations are affected by historical S&E degree production patterns, net immigration, occupational mobility, morbidity, and mortality. For each degree level and field, the greatest population density occurs during prime productive years—i.e., during the late 30s and throughout the 40s. (See figure 3-4.) This trend reflects the pattern of S&E degree production over the last 50 years—rapid growth with a more recent slowing. Scientists or engineers nearing traditional retirement and high mortality ages are far less numerous than those in the early stages of their careers. This age distribution has several implications for the S&E labor force:

- ◆ Barring very large reductions in degree production or increases in retirement rates, the number of trained scientists and engineers in the workforce will continue to increase for some time. The number of individuals who are now receiving S&E degrees greatly exceeds the number of S&E-trained workers who are near traditional retirement ages.
- ◆ The number of scientists and engineers reaching traditional retirement ages will increase dramatically over the next 25 years at every degree level.
- ◆ If there is less rapid growth in degree production than in the past, the average age of trained scientists and engineers in the labor force will increase. There are many advantages to having a more experienced S&E labor force. However, in many Ph.D. fields, the greatest productivity in terms of articles published often occurs early in an individual's career.

Figure 3-4.
Age distribution of employed scientists and engineers, by highest degree received: 1995



See appendix table 3-6.

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Sector of Employment

The private for-profit sector is by far the largest employer of S&E workers. In 1995, 72 percent of scientists and engineers with bachelor's degrees and 59 percent of those with master's degrees were employed in a private for-profit company. Academia was the largest sector of employment for those with doctorates (43 percent). Sectors employing smaller numbers of S&E workers include educational institutions other than four-year colleges and universities, nonprofit organizations, and state and local government agencies.

Among S&E occupations, there is a wide variation in the proportions of scientists and engineers employed in private for-profit industry. While nearly three-fourths of both computer and math scientists and engineers were employed in this sector, only one-fourth of life scientists and one-fifth of social scientists were so employed in 1995. (See appendix table 3-7.) Educational institutions employed the largest proportions of life scientists (49 percent) and social scientists (44 percent).

Text table 3-13.
S&E degree-holders employed in non-S&E occupations, by relationship of degree to job and highest degree received: 1995
(Percentages)

S&E degree obtained	Total number in non-S&E occupations	Relationshop of degree to job: Closely related	Somewhat related	Not related
All degree-holders	4,690,200	32.6	32.4	35.0
Bachelor's	3,821,100	29.0	32.9	38.1
Master's	699,200	48.3	29.8	21.9
Ph.D.	166,500	48.2	34.1	17.6
Other professional	3,400	71.5	0.0	28.5

SOURCE: National Science Foundation, Science Resources Studies Division, 1995 SESTAT (Scientists and Engineers Statistics Data System) Surveys of Science and Engineering College Graduates, unpublished tabulations.

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Salaries

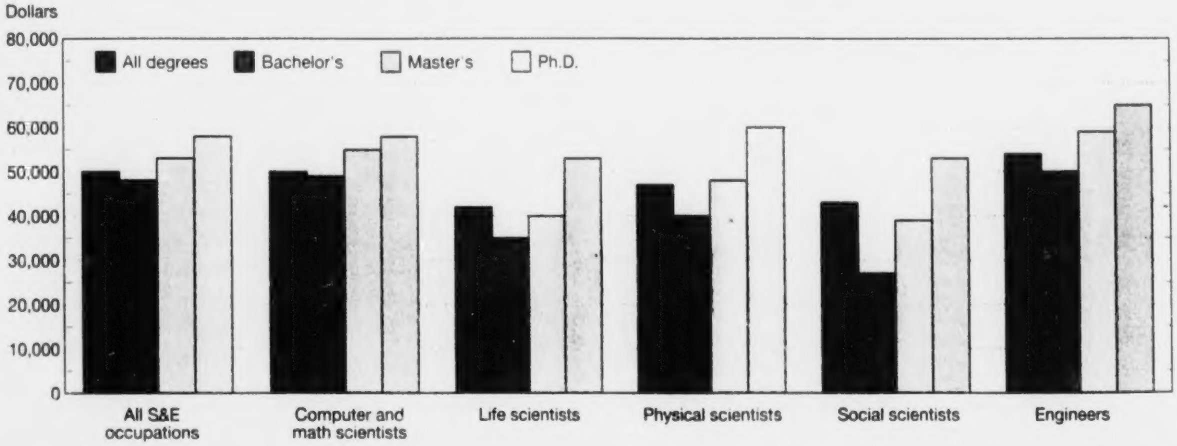
Median annual salaries of all S&E workers serve as an excellent indicator of the relative demand for workers in various S&E fields. In 1995, the median annual salary of employed bachelor's degree-holders was $48,000; for master's recipients, it was $53,000; and for doctorate-holders, $58,000. (See figure 3-5.) Engineers commanded the highest salaries at each degree level. The second highest salaries were earned by computer and math scientists at both the bachelor's and master's levels, and physical scientists at the doctorate level. The lowest median salaries were reported for social scientists at each degree level.

Median salaries for scientists and engineers rise steadily with the number of years since degree completion. For example, individuals who earned their bachelor's or master's degrees in the early 1990s earned about $15,000 less in 1995 than those who received their degrees in the early 1980s (NSF 1995c). For doctorate-holders, the difference is $18,000. (See text table 3-5 for salary comparisons of those with recent Ph.D.s.)

Women in the S&E Workforce

The U.S. workforce has experienced dramatic changes in its composition during the last half of the 20th century. These changes are attributable in large part to demographic changes stemming from immigration and from birth rates that differ

Figure 3-5.
Median annual salaries of employed scientists and engineers, by broad occupation and highest degree received: 1995



NOTE: Total includes other professional degree recipients.

See appendix table 3-8.

Science & Engineering Indicators –1998 among racial and ethnic subgroups in the United States. The majority of net new entrants to the workforce are women and minorities. These general trends are also reflected in the S&E workforce.

Employment by Field

Women comprised a little over 22 percent of the S&E workforce in 1995. (See figure 3-6.) Women are best represented in the social sciences, where they account for one-half of all workers; they are least represented in the physical sciences (22 percent) and engineering (9 percent). Among the science subfields, women are well-represented in biological sciences (40 percent) and in mathematics (33 percent). Within engineering subfields, women are best represented in chemical and industrial engineering (13 percent each) and least represented in aerospace and mechanical engineering (6 percent each).

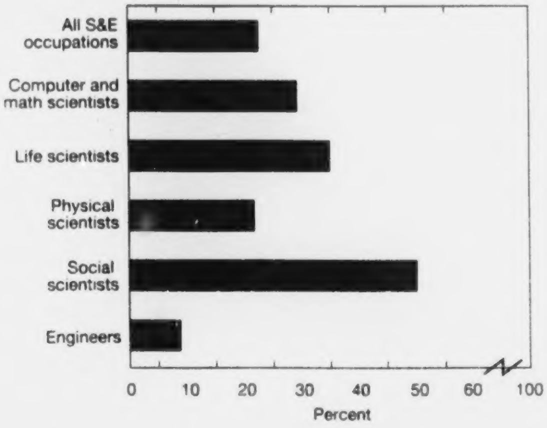
Highest Degree Level

By level of degree, 13 percent of women in S&E occupations report a doctorate as their highest degree—the same proportion as for men. (See appendix table 3-11.) Almost one-third of women report a master's as their highest degree, compared to 27 percent of men. The proportion of women in the S&E workforce is much greater for more recent graduation cohorts at all degree levels. With the exception of computer and math scientists, well over half of the women in each broad S&E occupation at every degree level received their degrees after 1984 (NSF 1995c).

Sector of Employment

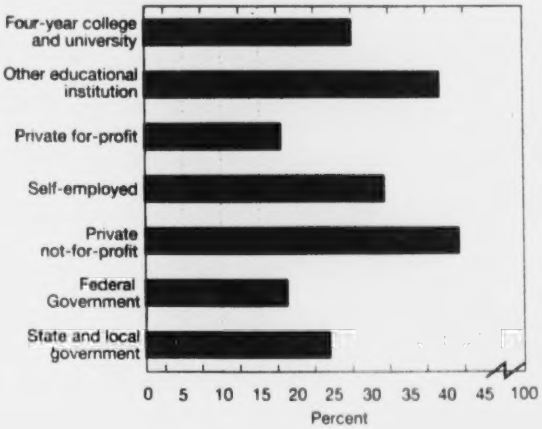
Women accounted for 28 percent of the scientists and engineers employed in four-year colleges and universities in 1995 and 39 percent of the S&E workers in other educational institutions. (See figure 3-7.) Only 18 percent of the scientists and engineers in private industry were female. However, this sectoral breakout was due to the extensive presence of women in social science occupations—a large proportion of which are jobs in educational institutions. Among the other employment sectors, women represented 42 percent of the S&E workers in private nonprofit organizations and 32 percent of self-employed scientists and engineers.

Figure 3-6.
Proportion of women in the S&E workforce, by broad occupation: 1995



See appendix table 3-10. *Science & Engineering Indicators – 1998*

Figure 3-7.
Women as a proportion of employed scientists and engineers, by sector of employment: 1995



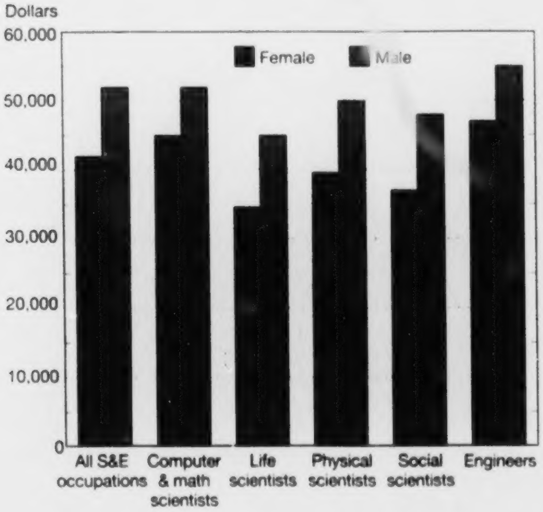
See appendix table 3-12. *Science & Engineering Indicators – 1998*

Sex and Salary

In 1995, the median annual salary for women scientists and engineers was $42,000—about 20 percent less than the $52,000 median annual salary for men. (See figure 3-8.) This difference could be influenced by several factors. For example, women were more likely than men to be working in educational institutions, in social science occupations, and in nonmanagerial positions; they also tended to have less experience than men. Among scientists and engineers in the workforce who have held their degrees five years or less, the median annual salary of S&E women was 85 percent that of men (NSF 1995c).

The salary differential varied greatly by field. In mathematics and computer sciences and in engineering occupations in 1995, women's salaries were approximately 14 percent less than men's. There was a 23 percent salary difference in social and life science occupations. Women also reported the highest and lowest median salaries in these occupations: women earned the highest median salary in engineering ($47,000) and the lowest in the life sciences ($34,600). (See appendix table 3-13.)

Figure 3-8.
Median annual salaries of employed scientists and engineers, by broad occupation and sex: 1995



See appendix table 3-13. *Science & Engineering Indicators – 1998*

Racial/Ethnic Minorities in the S&E Workforce

Minorities, except for Asians, are a small proportion of employed scientists and engineers in the United States. Asians, who make up 4 percent of the U.S. population (U.S. Bureau of the Census 1997), accounted for 10 percent of all S&E workers in 1995. Blacks and Hispanics made up 3.4 and 2.8 percent of the S&E workforce, respectively, in 1995; yet they represented 12 and 9 percent of the U.S. population. (See text table 3-14.)

Text table 3-14.
Distribution of employed scientists and engineers, by broad occupation and race/ethnicity: 1995
(Percentages)

Occupation	White	Black	Hispanic	Asian/ Pacific Islander	Native American
All scientists & engineers	83.9	3.4	2.8	9.6	0.3
Computer & math scientists	82.7	4.1	2.4	10.6	0.2
Life scientists	84.2	3.2	2.8	9.5	0.2
Physical scientists	84.8	2.8	2.5	9.6	0.3
Social scientists	87.5	5.2	3.1	3.7	0.5
Engineers	83.7	2.6	3.1	10.3	0.3

See appendix table 3-10. *Science & Engineering Indicators – 1998*

Employment by Field

Among broad S&E occupations, Asians—84 percent of whom are foreign-born (NSF 1995c)—are the best represented minority group in computer or math sciences, physical sciences, life sciences, and engineering. In each of these occupations, Asians account for around 10 percent.

The underrepresented minorities—blacks, Hispanics, and Native Americans—are more likely to enter the social sciences and least likely to enter the physical sciences. Blacks are the best represented minority group in social science occupations (5 percent). Blacks also account for 4 percent of computer and math scientists. (See appendix table 3-10.)

Highest Degree Level

Proportionately, Asians tend to have higher levels of education than whites or underrepresented minorities. Almost 60 percent of Asians in the S&E workforce have a master's or doctorate degree as their highest degree, compared to about 40 percent for whites and 35 percent for other minority groups. (See appendix table 3-11.)

Sector of Employment

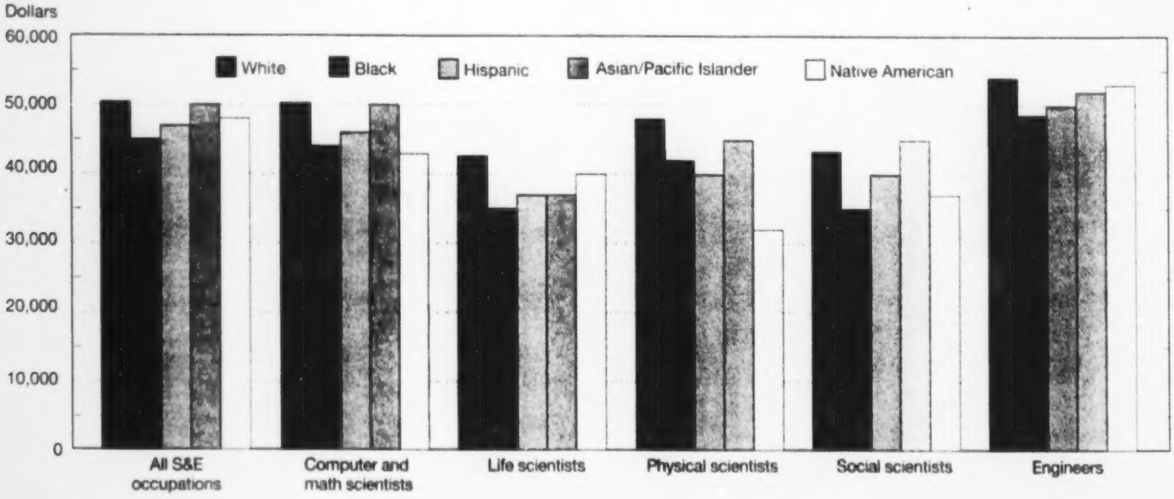
Representation of minority groups differs by employment sector. Asians are the best represented minority group in four-year colleges and universities (13 percent), in industry (10 percent), and in the other employment sectors. Blacks are the second best represented minority in the Federal Government (5.4 percent) and in state and local government (5.1 percent). (See appendix table 3-12.)

Salaries

Median annual salaries of Asian scientists and engineers in 1995 did not vary significantly from those of whites ($50,000 versus $50,400, respectively). In contrast, the salaries of other minority groups were generally 5 to 10 percent below that of whites. (See figure 3-9.) As with women, the salary difference was mostly due to the greater proportion of minorities in the lower paying social science occupations and to their having fewer years of work experience than whites. However, the salary gap almost disappears with more recent entrants into the S&E workforce (that is, those who received their degree five years ago or less), as the median annual salaries are about the same for all racial/ethnic groups (NSF 1995c).

In 1995, the highest median annual salaries for all racial/ethnic groups were in engineering occupations. Black engineers earned $48,600; Hispanic engineers, $50,000; Asian engineers, $52,000; and Native American engineers, $53,000. The lowest salaries for blacks were in social and life science occupations ($35,000); for Native Americans, physical science occupations were the lowest paying ($32,000); and for Hispanics, it was life science occupations ($37,000). (See appendix table 3-13.)

Figure 3-9.
Median annual salaries of employed scientists and engineers, by broad occupation and race/ethnicity: 1995



See appendix table 3-13.

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S&E Job Patterns in the Service Sector[13]

Although the service sector accounted for only 4 percent of the scientists, 10 percent of the engineers, and 26 percent of the technicians employed in the United States in 1994 (the latest year for which data are available), analysts look to service sector employment as a leading indicator of the health of the S&E labor market, given the economic shift from a manufacturing to a service-oriented base.[14] The term "service sector" as used here denotes establishments engaged in wholesale and retail trade, transportation, communication, and utilities. Employment of scientists, engineers, and technicians in the service sector increased from 1988 to 1991, then dropped sharply from 1991 to 1994. By 1994, the number of employed scientists and engineers in service industries (185,200) was 8 percent below the 1988 level of 202,000 and 15 percent below the 1991 level of 219,000.[15] (See text table 3-15.)

Engineering and technician employment was particularly affected by the downturn, as the 1994 total of 129,800 engineers employed in the service sector represented a drop of 11 percent from 1988 and 16 percent from 1991. Technician employment dropped 12 percent over the six-year period. Although employment of scientists dropped 13 percent between 1991 and 1994, the overall decline for the 1988-94 period was negligible.

Principal Employers

As described here, the service sector is divided into three major industry groups: (1) transportation, communications, and utilities; (2) wholesale trade; and (3) retail trade. Within these groups, three industries accounted for 80 percent of total employed scientists and engineers in the service sector in 1994, down from 85 percent in 1988:

- wholesale trade—durable goods, 31 percent of service sector S&E employment in 1994;
- utilities (electric, gas, and sanitary services), 29 percent; and
- communications, 20 percent.

Most of the total sectoral drop in S&E employment between 1988 and 1994 occurred in wholesale trade—durable goods, where 13,500 S&E jobs (19 percent of the industry's 1988 S&E workforce) were lost; and in communications, where 9,000 S&E jobs (20 percent of the industry's 1988 S&E workforce) were lost. (See figure 3-10.)

Partially offsetting the sizable loss in these two industries were gains in wholesale trade—nondurable goods, which provided 2,900 jobs, representing 35 percent of the industry's 1988 S&E workforce; and retail trade, with

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[13] Information in this section is from NSF (1997d).

[14] Service sector industries are those included in Standard Industrial Classification codes 40-59. Excluded are educational services and state and local governments. Other industries traditionally thought of as "service" industries—such as financial, insurance, real estate, and legal service; entertainment; health services; social services; and hotels and other lodging places—are covered under a separate survey cycle on nonmanufacturing industries; these were last reported on by NSF (forthcoming). Note that the industry groups referred to here as the "service sector" were denoted as "trade and regulated industries" in previous survey cycles.

[15] These data are compiled from the Occupational Employment Statistics survey conducted by the U.S. Bureau of Labor Statistics, with support from NSF. (See NSF 1997c.) Until 1996, U.S. business establishments were surveyed once every three years, with roughly one-third of the establishments covered each year. Starting with the 1996 survey cycle (for which data are not yet available), all establishments employing nonfarm wage and salary workers are being surveyed annually.

Text table 3-15.
Scientists, engineers, and technicians employed in service sector

Occupation	1988	1991	1994
All scientists, engineers, technicians	472,500	477,900	422,700
All scientists & engineers	202,000	219,000	185,200
Scientists	55,500	63,900	55,400
Engineers	146,500	155,100	129,800
Technicians	270,500	258,900	237,500

SOURCE: National Science Foundation, Science Resources Studies Division, "Services Sector S&E Employment Rises, Then Falls Sharply as Engineering and Technician Jobs Are Cut," Data Brief, NSF 97-322 (Arlington, VA: 1997).

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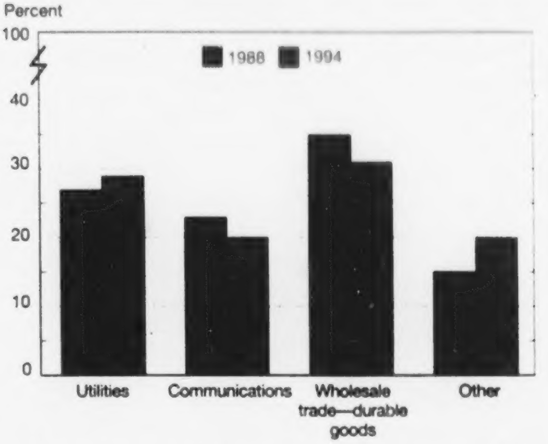
Figure 3-10.
Distribution of service sector S&E jobs, by major industry group



SOURCE: National Science Foundation, Science Resources Studies Division, "Services Sector S&E Employment Rises, Then Falls Sharply as Engineering and Technician Jobs Are Cut," Data Brief, NSF 97-322 (Arlington, VA: 1997).

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3,300 new jobs, representing 34 percent of the industry's 1988 S&E workforce, over the six-year period. In 1994, however, combined total S&E employment in these latter two industries constituted only 13 percent of sectoral S&E employment (3 percent in wholesale trade—nondurable goods and 10 percent in retail trade), which was down from 1991 levels in both industries.

Employment of Scientists

At first glance, scientists might appear to have escaped the decline experienced by their engineer and technician counterparts, as total 1994 employment of 55,400 scientists in the service sector was virtually unchanged from the 1988 figure of 55,500. However, employment of scientists had jumped to 63,900 (an increase of 15 percent) between 1988 and 1991 before falling back in 1994 to the earlier level.

Among service industries employing at least 1,000 scientists in 1991, science employment in all but one declined—often dramatically—between 1991 and 1994. These industries included general merchandise stores and air transportation (both down by 34 percent); trucking and warehousing (down 29 percent); transportation services (down 25 percent); wholesale trade—durable goods (down 20 percent); furniture and home furnishings stores (down 18 percent); wholesale trade—nondurable goods (down 13 percent); miscellaneous retail (down 5 percent); and electric, gas, and sanitary services (down 4 percent). Only in communications was there a 1991-94 increase in employment of scientists (3 percent) (NSF forthcoming).

Employment of Engineers

Of the 19 service sector industries, three accounted for 87 percent of all employed engineers in 1994:

- wholesale trade—durable goods, 45,700 (35 percent);
- electric, gas, and sanitary services, 39,900 (31 percent); and
- communications, 27,000 (21 percent).

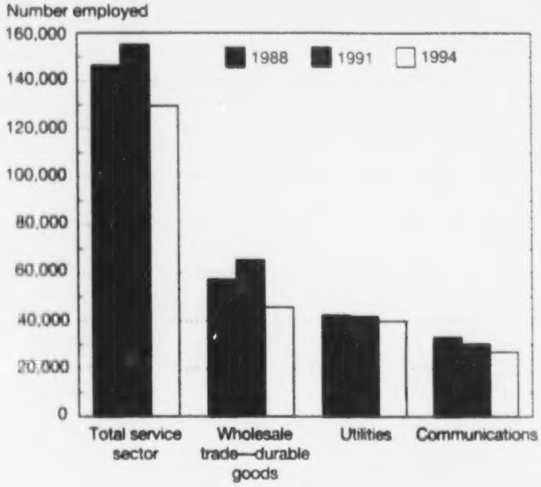
All three industries suffered declines in engineering employment over the full six-year period 1988-94 and over the shorter 1991-94 period. Wholesale trade—durable goods lost 19,800 engineering jobs between 1991 and 1994 (35 percent of the industry's 1988 engineering workforce and 30 percent of its 1991 engineering workforce). Engineering job losses were more moderate in the other two large service industries. Electric, gas, and sanitary services lost 2,400 (6 percent) of its 42,300 1988 engineering jobs; and communications lost 6,100 (18 percent) of its 33,100 1988 engineering positions. (See figure 3-11.)

Among smaller service industries employing at least 1,000 engineers in 1991, a substantial 1988-94 decline in engineering employment was suffered only by air transportation (a 4 percent decline, but dropping to 33 percent of its 1991 level). All other such service industries either maintained or increased their employment of engineers. Industries employing at least 1,000 engineers and experiencing 1988-94 increases included miscellaneous retail (67 percent), water transportation (60 percent), furniture and home furnishings stores (40 percent), and wholesale trade—nondurable goods (23 percent).

Employment of Technicians

Service sector employment of technicians was dominated by the same three industries as engineering in 1994—and, with 85 percent of this group, almost to the same extent. Wholesale trade—durable goods employed 92,300 (39 percent) of the sector's technicians and experienced the most significant declines—a loss of 10,800 jobs (4 percent) between 1988 and 1991, and an additional 13,400 jobs (13 percent) between 1991 and 1994. The combined loss of 24,200 technician jobs in wholesale trade—durable goods from 1988 to 1994 represented 73 percent of the lost technician jobs in the entire service sector over a six-year period.

Figure 3-11.
Engineering employment in the service sector, by major industry group



SOURCE: U.S. Bureau of Labor Statistics, Occupational Employment Statistics Survey.

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Communications, the second largest technician-employing service sector (64,300 jobs, or 27 percent of the sectoral total in 1994) lost 5,200 jobs between 1988 and 1991, but gained 3,000 of these back between 1991 and 1994. Electric, gas, and sanitary services—the third largest employer of technicians in the service sector—lost 5,200 (8 percent) of its 66,500 1988 technician jobs. Like communications, it gained 3,000 of these positions back between 1991 and 1994.

Scientists and Engineers in an International Context: Migration and R&D Employment

Foreign-Born Scientists and Engineers in the United States

In April 1993, 23.0 percent of individuals holding science and engineering doctorates in the United States were foreign-born.[16] (See text table 3-16.) Of these, 34.1 percent received their S&E doctorates from a foreign school. At the bachelor's degree level, 9.8 percent of those with S&E degrees were foreign-born, with 49.1 percent of degrees from foreign schools.

The relative proportions of foreign-born doctorate-holders resident in the United States vary by S&E field. Psychology had the lowest percentage of foreign-born doctorate-holders in 1993 (9.0 percent), and civil engineering had the highest (50.6 percent). In general, the percentage of immigrants was highest in fields with favorable labor market conditions (as measured by unemployment and IOF rates), such as engineering and the computer sciences. It was lowest in the social sciences (except for economics); the life sciences; and the earth, atmospheric, and oceanographic sciences.

In recent years, the number of perm anent visas issued by the U.S. Immigration and Naturalization Service (INS) to immigrants in S&E occupations has been greatly affected by immigration legislation and administrative changes at INS. The 1990 Immigration Act led to increases in the number of employment-based visas available starting in 1992.[17] (See figure 3-12.) Further, the 1992 Chinese Student Protection Act made it possible for Chinese nationals in the United States on student or other temporary

Text table 3-16.
Share of S&E degrees held by foreign-born recipients, by highest degree received: 1993
(Percentages)

Degree field	Bachelor's degree	Master's/other professional degree	Ph.D. degree
All S&E	9.8	18.0	23.0
Life sciences	8.0	15.0	21.3
Agricultural sciences	5.6	16.0	20.7
Biological sciences	9.4	15.5	21.5
Math/computer sciences	11.3	21.9	33.6
Computer sciences	13.6	29.0	39.4
Mathematics	9.2	13.2	31.1
Physical sciences	11.3	17.1	25.9
Chemistry	14.8	23.6	25.7
Earth, atm. & ocean.	5.2	9.7	16.8
Physics/astronomy	11.2	20.0	30.6
Social sciences	6.7	10.1	13.1
Economics	11.1	25.5	23.6
Political science	6.9	12.4	14.9
Psychology	5.9	6.1	9.0
Sociology/anthropology	4.4	13.1	14.4
Engineering	13.9	28.4	40.3
Chemical	17.0	32.5	38.6
Civil	17.3	36.4	50.6
Electrical/electronic	14.8	28.6	39.1
Mechanical	12.8	30.3	38.1
Non-S&E	6.8	7.7	12.4

NOTE: Data include all people residing in the United States at the time of the survey with a degree in science and engineering, regardless of where that degree was earned.

SOURCE: National Science Foundation, Science Resources Studies Division, 1993 National Survey of College Graduates.

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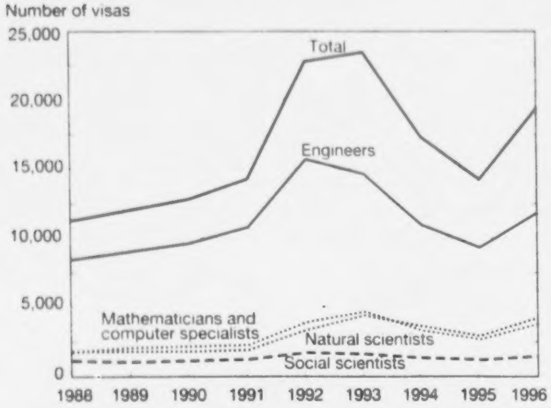
[16] These estimates are taken from the 1993 National Survey of College Graduates, which, because it samples from decennial census records—rather than, like most surveys of scientists and engineers, from lists of graduates of U.S. schools—will be the best source of data for determining the percentage of scientists and engineers that are foreign born until about 2004.

[17] Because many immigrants—including scientists and engineers—enter the United States on family-based visas, where reporting of occupation is optional, S&E occupations might be undercounted.

Figure 3-12.
Permanent visas issued to immigrant scientists and engineers



SOURCES: Immigration and Naturalization Service, <<http://www.ins.usdoj.gov/stats>>; and National Science Foundation, Science Resources Studies Division, *Nonacademic Scientists and Engineers: Trends From the 1980 and 1990 Censuses*, NSF 95-306 (Arlington, VA).

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visas to acquire permanent resident visas. In addition to these legislative acts, changes in procedures for visas led alternatively to surges and backlogs in applications. Aside from these short-term effects, there appears to have been little change in the growth of S&E immigration.

Stay Rates of Foreign Recipients of U.S. Ph.D.s

How many of the foreign students who receive S&E Ph.D.s from U.S. graduate schools stay in the United States? According to a report by Michael Finn (1997) of the Oak Ridge Institute for Science and Education, 47 percent of 1990-91 U.S. S&E doctorate recipients with temporary visas were still in the United States in 1995.[18] By field, this percentage ranged from 28 percent in the social sciences to 53 percent in engineering and the physical sciences. (See text table 3-17.) The overall stay rate for S&E doctoral visa-holders in 1995 was also 47 percent for the 1970-72 cohort.[19] The percentage of this cohort in the United States is stable over time, as 51 percent were in the United States in 1980 as well (Finn 1997). It is quite possible, however, that some of this stability comes from individuals in this cohort reentering the United States in mid-career, replacing others who leave the United States in mid-career. (For more information on this topic, see chapter 2, "Foreign Doctoral Students in the United States." For a discussion of the obverse phenomenon—emigration of U.S.-born Ph.D. recipients—see "How Many U.S. Scientists and Engineers Go Abroad?")

Text table 3-17.
Foreign recipients of U.S. Ph.D. degrees residing in the United States in 1995
(Percentages)

Ph.D. degree field	1990-91 Ph.D.s (temporary visas)	1970-72 Ph.D.s (temporary & permanent visas)
All S&E	47	47
Life sciences	45	36
Physical sciences and mathematics	53	57
Social sciences	28	30
Engineering	53	58

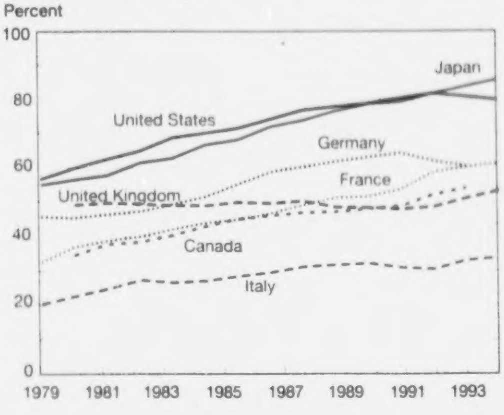
See appendix table 2-38.

Science & Engineering Indicators – 1998

International R&D Employment

Japan continues to surpass the United States in terms of the proportion of the country's labor force comprised of R&D-performing scientists and engineers. (See figure 3-13.) Both countries lead the remaining G-7 nations (Germany, France, the United Kingdom, Italy, and Canada), although the U.S. share of total G-7 scientists and engineers engaged in R&D has fallen slightly—dropping from 48.0 percent in 1981 to 44.7 percent in 1993. (See figure 3-14.)

Figure 3-13.
Scientists and engineers engaged in R&D per 10,000 labor force, by country



NOTE: German data are for West Germany only before 1989.

See appendix table 3-15.

Science & Engineering Indicators – 1998

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[18] These estimates were derived by matching records from NSF's Survey of Earned Doctorates to earnings records from the U.S. Social Security Administration. Statistical adjustments for limits to Social Security coverage were made by comparing against coverage rates for native-born doctorate-holders.

[19] Data from the NSF Survey of Earned Doctorates do not allow for distinctions between temporary and permanent visas from this period.

How Many U.S. Scientists and Engineers Go Abroad?

In 1995, at least 19,600 U.S. native-born, naturalized citizen, and permanent resident Ph.D. scientists and engineers lived outside the United States.* (See text table 3-18.) These included:

- 3.3 percent (13,900) of native-born S&E doctorates,
- 7.4 percent (1,400) of foreign-born S&E doctorates with U.S. citizenship at time of degree, and
- 13.6 percent (4,300) of permanent residents at time of degree.

Not included are U.S. citizen Ph.D. scientists who had had only a temporary student visa or work visa when they received their Ph.D.; it may be reasonable to assume that this group is as likely to work outside the United States as those who had already been naturalized by the time of degree.

The likelihood of foreign residence for U.S. natives is greatest for those with the most recent degrees—ranging from 2.1 percent of 1945-54 native-born Ph.D. recipients to 3.4 percent of 1985-94 native-born Ph.D. recipients. By field, the proportion of native-born Ph.D.s resident in foreign countries is greatest in the mathematical and computer sciences and in the social sciences (4.2 percent for each). It is lowest in the physical sciences.

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*Good estimates of the number of U.S. scientists and engineers who work abroad are not available, and the numbers presented here should be treated as lower bound estimates for several reasons. These estimates are based on a match of administrative data from the NSF 1995 Survey of Doctorate Recipients to individual data from the NSF Doctoral Record File created from the Survey of Earned Doctorates. The National Research Council (NRC) attempted to identify when a nonresponse was due to the sampled individual residing outside the United States as of the April reference date. To the extent that individuals residing outside the United States are more prevalent in the sample portion never located by NRC than they were in the located sample, these numbers will underestimate the extent of emigration. Note that, since a short-term trip abroad would not count as residence, and since the SDR data are collected over several months, there is little danger of miscategorizing a short absence as working abroad. There is, however, a somewhat greater danger of listing a person as living abroad who left the United States for many years and has since returned.

Text table 3-18.
Lower bound estimates of U.S. citizen and permanent resident Ph.D. graduates residing outside the United States: 1995

	Native born		Foreign-born with citizenship at time of Ph.D.		Permanent resident at time of Ph.D.		Total citizen or permanent resident at time of Ph.D.	
Ph.D. degree field	No.	% abroad	No.	% abroad	No.	% abroad	No.	% abroad
All S&E	13,900	3.3	1,400	7.4	4,300	13.6	19,600	4.1
Life sciences	3,400	2.7	200	5.0	900	12.0	4,500	3.3
Math and computer sciences	1,000	4.2	100	4.2	200	10.2	1,200	4.6
Physical sciences	2,200	2.5	300	8.7	800	12.6	3,200	3.3
Social sciences	5,900	4.2	300	7.5	1,200	18.0	7,400	4.9
Engineering	1,500	3.0	500	9.1	1,300	13.1	3,300	5.0

SOURCE: National Science Foundation, Science Resources Studies Division, Doctorate Record File and administrative records associated with collection of the 1995 Survey of Doctorate Recipients.

NOTE: Number and percent abroad data are estimated minimums.

Science & Engineering Indicators – 1998

Projected Demand for S&E Workers[20]

During the 1996-2006 period, employment in S&E occupations is expected to increase at more than three times the rate for all occupations. While the economy as a whole is anticipated to provide approximately 14 percent more jobs over this decade, employment opportunities for S&E jobs are expected to increase by about 44 percent, or about 1.36 million jobs. (See figure 3-15.)

Approximately three-fourths of the increase in S&E jobs will occur in computer-related occupations. For a discussion of the labor market impacts resulting from the demand for employment in information technology-producing industries, see chapter 8, "IT and Employment." Overall employment in these occupations across all industries is expected to double over the 1996-2006 decade, with over 1 million new jobs being added. Jobs for computer engineers and scientists are expected to increase from 427,000 to 912,000, while employment for computer systems analysts is expected to grow from 506,000 to slightly over 1 million jobs.

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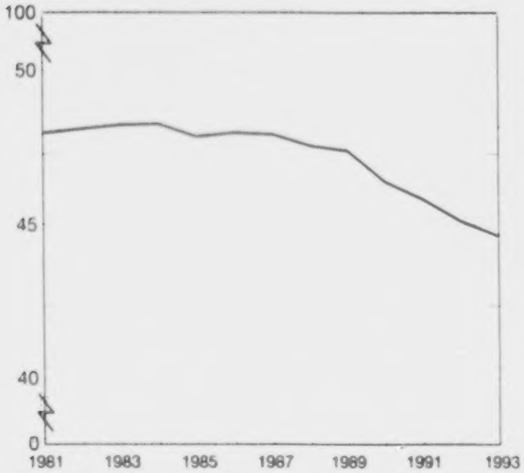
[20] Data in this section are from U.S. BLS (1997).

Figure 3-14.
U.S. scientists and engineers engaged in R&D, as a percentage of the G-7 total



NOTE: G-7 nations are the United States, Japan, Germany, the United Kingdom, France, Canada, and Italy.

SOURCE: Organisation for Economic Co-operation and Development, Main Database (Paris: 1997).

Science & Engineering Indicators – 1998

Within engineering, electrical/electronic engineering is projected to have the biggest absolute and relative employment gains, up by 105,000 jobs, or nearly 29 percent. Civil and mechanical engineers are also expected to experience above average employment gains, with projected increases of about 18 and 16 percent, respectively. Employment for all engineering occupations is expected to increase by an average of approximately 18 percent.

Job opportunities in life science occupations are projected to grow by almost 23 percent (41,000 new jobs) over the 1996-2006 period; at 24 percent, the biological sciences are expected to experience the largest growth (20,000 new jobs). Employment in physical science occupations is expected to increase by about 17 percent, from 207,000 to 242,000 jobs; about half of the projected job gains are for chemists (17,000 new jobs).

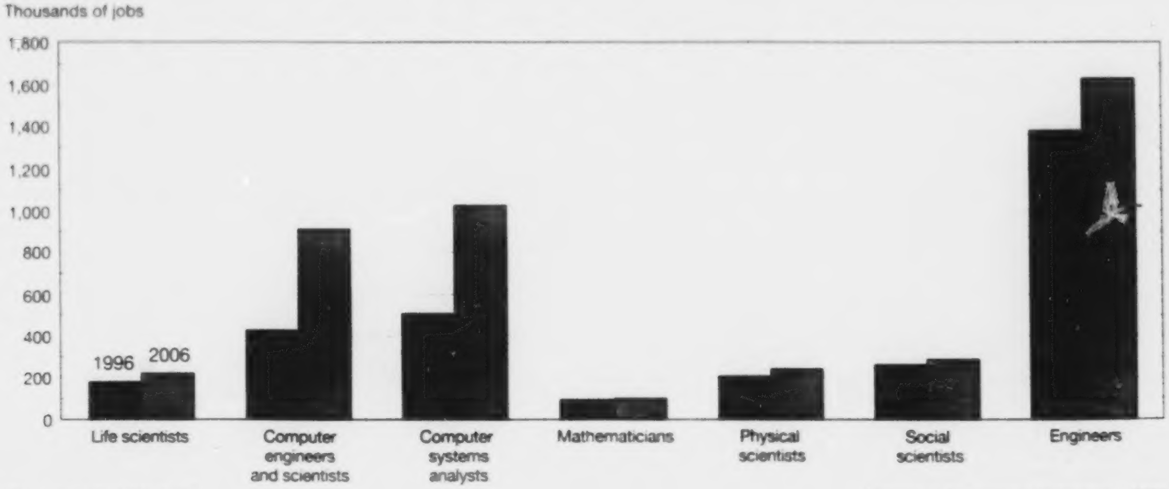
Social science occupations are expected to experience below average job growth (10 percent) over the decade, largely due to the modest employment increases anticipated for psychologists (8 percent, or 11,000 new jobs). Economists, however, are projected to experience more favorable job growth (18 percent, or 9,000 new jobs).

Conclusion

There were few changes in labor market conditions for scientists and engineers between 1993 and 1995, the most recent year for which comprehensive data are available. For Ph.D. scientists and engineers, the unemployment rate was essentially unchanged—moving from 1.6 to 1.5 percent. A similarly slight change held for recent S&E Ph.D. recipients, whose unemployment rate went from 1.7 to 1.9 percent and whose IOF rate increased from 4.0 to 4.3 percent. Unemployment rates across all S&E occupations were also low for bachelor's (2.1 percent) and master's (2.5 percent) degree level scientists and engineers.

While the vast majority of new Ph.D. scientists and engineers do find work that is relevant to their training, indicators of labor market difficulties exist in several fields. In physics,

Figure 3-15.
S&E jobs, by broad occupation: 1996 and projected 2006



See appendix table 3-16.

Science & Engineering Indicators – 1998

unemployment rates for recent Ph.D.s have dropped to 2.9 percent, but the IOF proportion has increased to 6.7 percent, with placement in tenure-track positions at a historical low. For recent Ph.D. biological scientists, unemployment and IOF rates are low, but so is pay; and the drop in the percentage of tenure-track positions is the greatest of any field. Relative labor market difficulties also exist for recent Ph.D. graduates in political science; mathematics; sociology/anthropology; and the earth, atmospheric, and oceanographic sciences.

While postdoctoral appointments for additional training have become more prevalent over time in most S&E fields, labor market difficulties have stymied their increased use. Exceptions may include both physics—where multiple postdoctorate appointments are becoming more common than in the past—and the earth, atmospheric, and oceanographic sciences—where 29.3 percent of postdoctorates said they took their appointments primarily because other employment was not available.

The future of the S&E labor market is difficult to forecast for any number of practical reasons, but some indicators do exist. On the demand side, the U.S. Bureau of Labor Statistics predicts an increase in S&E jobs of 44 percent between 1996 and 2006—a growth rate three times faster than that for all occupations. The supply of individuals in the labor market with S&E degrees at all levels is likely to continue to increase even if there is no growth in degree production: current graduate numbers are much greater than the number of employed scientists now nearing traditional retirement ages. The same age structure of S&E workers suggests, however, that the number of scientists and engineers retiring will increase dramatically over the next 25 years even if the average retirement age increases.

While changes in earnings and unemployment rates are impossible to predict, on balance these factors suggest a future S&E labor force that is larger and older. Further, this labor force will generally be able to find employment that make use of its training, though not necessarily in tenured academic positions.

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Chapter 4

U.S. and International Research and Development: Funds and Alliances

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Highlights

NATIONAL TRENDS IN R&D EXPENDITURES

- **Expenditures on research and development (R&D) performed in the United States reached a record-setting high in 1997, exceeding an estimated $200 billion for the first time.** In addition, the rate of growth in R&D investment in the mid-1990s was the highest it has been since the early 1980s, in contrast to a period earlier in the decade when increases in R&D spending failed to keep pace with inflation.

- **Profit-making companies are responsible for the current upward trend in R&D investment in the United States.** The most recent data show industrial firms providing $2 out of every $3 (an estimated $133.3 billion in 1997)—and spending $3 out of every $4 (an estimated $151.4 billion)—invested in R&D in the United States. Both proportions have been edging upward almost continuously for the past quarter century. Increases in the mid-1990s in industrial R&D are the highest recorded since the early 1980s and are largely attributable to record-setting profits, intense international competition, and the introduction of new capabilities in information technology. In addition, in many firms, external research funding is growing at a rate faster than internal spending.

- **The Federal Government, which has been steadily losing ground to industry as a national source of R&D funds, provided an estimated $62.7 billion in R&D support in 1997.** Federal R&D funding has fallen almost continuously in real terms for a decade, although the descent seems to have tapered off in the mid-1990s. In 1997, federal agencies provided 30 percent of all monies spent on R&D in the United States, down from 46 percent a decade earlier (at the peak of the defense buildup).

- **The decline in federal R&D funding is reflected in data for each of the R&D-performing sectors—except academia—but is most visible in data showing federal support of industry R&D.** In other words, the impact of defense downsizing on R&D performance can be seen most clearly in the industry-reported R&D numbers. In 1997, federal support of industry-performed R&D was an estimated $20.8 billion, down about $8 billion from 10 years earlier. Between 1987 and 1997, the federal share of total industry R&D performance declined dramatically—from 32 percent to an unprecedented 14 percent. It should be noted that the federal share of the industry total has been shrinking almost continuously since at least 1970, because industry's own funding has either outpaced or has not declined as rapidly as federal support.

- **Academia is the only R&D-performing sector that did not experience a cutback in federal support during the 1990s.** The annual rate of growth in federal support, however, has been falling fairly steadily for more than a decade, e.g., little real growth is expected for 1995-97. The growth-rate decline can be attributed to efforts to balance the budget and reduce the deficit.

- **All three categories of R&D funding—basic research, applied research, and development—contributed to the overall growth in R&D spending in the United States in the mid-1990s: all three are at their highest levels ever recorded, in both current and constant dollars.** All of the growth, however, took place in the private sector. In terms of R&D financial support, the Federal Government's share of total funding for each of the three categories dropped between 1987 and 1997, with particularly severe declines for applied R&D.

- **The nonmanufacturing sector now accounts for approximately one-fourth of all industrial R&D investment in the United States; this is considerably greater than in earlier decades.** This higher profile is largely attributable to the growth of the information technology (especially software) and biotechnology industries. Firms in these two categories could seem to be taking over the annual list of the 100 largest R&D-performing companies.

- **Among the six largest R&D-performing manufacturing industries, companies classified in the electrical equipment industry exhibited both the largest absolute increase ($8.2 billion) and the highest percentage increase (92 percent) in nonfederal R&D expenditures between 1991 and 1995.** The additional electrical equipment industry monies appear in the electronic components segment, which accounted for 56 percent of R&D dollars in that industry in 1995 and experienced a three-fold increase in R&D spending between 1991 and 1995.

- **Pharmaceutical companies' R&D spending nearly tripled between 1985 and 1995.** The most prominent trend in the drugs and medicines industry has been the melding of pharmaceutical and biotechnology research: e.g., more than one-third of drug companies' R&D projects are primarily biotechnology-related. In addition, the rapid growth of R&D dollars reflects the high cost of research directed at the discovery of cures and treatments for diseases like AIDS, other viruses, and drug-resistant bacteria.

- **Total federal R&D obligations were an estimated $68.1 billion in fiscal year 1997, 12 percent below the 1989 level (in real dollars), the peak year of federal R&D investment.** Defense downsizing, which affected programs at both the Departments of Defense (DOD) and Energy, fueled the overall decline.

- **For the first time since 1981, DOD is expected to account for less than half (48 percent) of the federal R&D total.** The DOD share of federal R&D spending has been declining steadily since the mid-1980s. In 1986, at the height of the defense buildup, it accounted for approximately two-thirds of the total.

- **Cooperative R&D is now an important tool in the development and leveraging of science and technology (S&T) resources. There has been a major upswing in the number of inter- and intra-sector and international S&T partnerships since the early 1980s.** For example, the annual number of new research joint ventures has been growing in most years, with the largest increases occurring in 1995 and 1996, bringing the total number of these research collaborations up to 665 by the end of 1996.

- **The increase in research joint ventures may reflect, to some extent, companies' participation in the U.S. Department of Commerce's Advanced Technology Program (ATP).** Between 1990 and 1996, more than $2 billion in public and private funds were invested in 288 ATP projects. ATP funding was cut substantially in 1996.

- **Technology transfer activities became an important mission component of federal laboratories in the late 1980s.** Although more than 3,500 new cooperative research and development agreements (CRADAs) were executed between 1992 and 1995, government agencies now seem to be backing away from these collaborative research arrangements. The U.S. Council on Automotive Research—better known as the Clean Car Agreement or the Partnership for a New Generation of Vehicles—executed 32 CRADAs in 1995.

- **The elimination in 1995 of the Technology Reinvestment Project affected DOD's "dual-use" strategy of providing financial support to the private sector to develop and deploy those technologies with likely applications in both the commercial and military sectors.** This project was replaced in 1997 by the much smaller Dual-Use Applications Program.

INTERNATIONAL TRENDS IN R&D EXPENDITURES

- **The United States accounts for roughly 44 percent of the industrial world's R&D investment total and continues to outdistance, by more than 2 to 1, the total research investments made by Japan, the second largest performer.** Not only did the United States spend more money on R&D activities in 1995 than any other country, it also spent nearly as much by itself as the rest of the major industrialized "Group of Seven" (G-7) countries combined—Japan, Germany, France, the United Kingdom, Italy, and Canada. However, in terms of nondefense R&D spending, combined expenditures in these six countries exceeded nondefense R&D spending in the United States by 18 percent.

- **Total R&D expenditures stagnated or declined in each of the largest R&D-performing countries in the early 1990s, but has since recovered in the United States and Japan.** There was a worldwide slowing in R&D spending in both large and small industrialized countries in the early 1990s. In fact, inflation-adjusted R&D spending fell for three consecutive years (1992, 1993, and 1994) in both the United States and Japan. Among the G-7 countries, only the United States and Japan showed an apparent reversal of this trend in 1995, with the total R&D effort rising by 6 percent in both countries (in constant dollars and constant yen, respectively).

- **In the United States, the recovery in total R&D spending and its R&D to gross domestic product (GDP) ratio is the result of increased expenditures on nondefense activities.** The U.S. R&D/GDP ratio has inched back up to 2.6 percent in 1997 from its 16-year low of 2.4 percent in 1994. The 1997 nondefense R&D/GDP ratio is estimated at 2.2 percent, a historical high.

- **R&D spending in the Russian Federation and in many of the former communist countries in Europe remains considerably below levels in place before the introduction of market economies.** R&D downsizing and restructuring of obsolete, state-owned (generally military-oriented) enterprises are necessary to establish viable commercial and scientific R&D infrastructures in these countries.

- **Worldwide changes in the R&D landscape are presenting governments with unparalleled issues of refocusing purpose and direction in S&T policies.** Defense R&D has been substantially reduced not only in the United States, but also in the United Kingdom and France, where the national defense share of the government R&D total has declined from 44 to 41 percent, and from 40 to 29 percent, respectively.

- **Among nondefense functions, U.S. Government R&D spending for health is far greater than for any other activity.** From 1990 to 1998, health R&D is expected to grow by 26 percent (in constant dollars) while funding for all other nondefense functions will grow by just 3 percent. Health programs now account for 18 percent of the U.S. federal R&D funding total. The greatest growth is in AIDS-related research.

- **Many countries have put into place fiscal incentives to increase the overall level of R&D spending and to stimulate industrial innovation.** Practically all industrialized countries (including the United States) allow industry R&D expenditures to be 100 percent expensed in the year they are incurred, and about half of the countries (including the United States) provide some type of additional R&D tax credit. From 1990 to 1996, U.S. industry received an estimated $12 billion through tax credits on incremental research and experimentation expenditures. About 15 states offer additional R&D tax credits.

◆ **Industrial firms increasingly are using global research partnerships to strengthen core competencies and expand into technology fields critical for maintaining market share.** Since 1986, companies worldwide have entered into over 4,000 known multi-firm R&D alliances involving strategic high-technology activities. More than one-third of these alliances were between U.S. firms and European or Japanese firms. Most of the alliances were created to develop and share information technologies.

◆ **Substantial R&D investments are made by U.S. companies overseas.** From 1985 to 1995, U.S. firms' investment in overseas R&D increased three times faster than did company-funded R&D performed domestically (10.1 percent versus 3.4 percent average annual constant-dollar growth). Equivalent to about 6 percent of industry's domestic R&D funding in 1985, overseas R&D now amounts to 12 percent of U.S. industry's on-shore R&D expenditures. Most (72 percent) of U.S.-funded R&D was performed in Europe—primarily Germany, the United Kingdom, and France. Pharmaceutical companies accounted for the largest industry share (20 percent of U.S. 1995 overseas R&D), which was equivalent to 25 percent of their domestically financed R&D.

◆ **Substantial R&D investments are made by foreign firms in the United States.** From 1987 to 1995, inflation-adjusted R&D growth from majority-owned U.S. affiliates of foreign firms averaged 12.5 percent per year. This growth contrasts favorably with the implied 3 percent average annual rate of increase in U.S. firms' domestic R&D funding. R&D expenditures in the United States by foreign companies are now roughly equivalent to U.S. companies' R&D investment abroad. Germany, Switzerland, the United Kingdom, France, and Japan collectively account for 75 percent of this foreign funding. Foreign-funded research in 1995 was concentrated in drugs and medicines, industrial chemicals, and electrical equipment industries. More than 670 foreign-owned R&D facilities are located in the United States.

Introduction

Chapter Overview

Research and development (R&D) appear to be benefiting from the economic prosperity of the mid-1990s. Businesses are thriving, jobs are being created, and inflation seems to be under control. A recent upswing in R&D spending in the United States is paralleling these and other positive economic trends. The annual level of R&D expenditures is estimated to have reached a record-setting high in 1997, exceeding $200 billion for the first time. In addition, the rate of growth in R&D investment is the highest it has been since the early 1980s, a welcome contrast to a period in the early 1990s when it failed to keep pace with inflation.

What is driving the recent R&D expansion? It is not the Federal Government, which is continuing to curtail its support of defense-related R&D activities. Instead, almost all of the acceleration is attributable to industrial firms. Simply stated, many firms are reaping record profits, which is creating a profitable climate for investment in innovation.

The invention of new and improved products, processes, and services has a pervasive impact on the quality of life and the standard of living in the United States and other industrialized nations. Although a negligible portion of the world's financial and human resources is invested in R&D, advancements in science and technology (S&T) often deliver huge and crucial payoffs in terms of economic growth and prosperity, national security, and the health and well-being of society.

A number of new trends in U.S. R&D investment have emerged in recent years, including:

◆ an increase in R&D performed in the service sector;

◆ an upsurge in state spending on cooperative technology programs;

◆ elevated political disharmony over the role of the Federal Government in technology development;

◆ a mushrooming of collaborative R&D efforts within and across sectors and with international partners; and

◆ rapid growth in global R&D expenditure flows, including the rise in U.S. industry's overseas R&D investment, as well as foreign R&D investment in the United States.

In addition, federal spending priorities have been gradually changing. Pressure to balance the budget, combined with defense downsizing (which began in the late 1980s after the end of the Cold War), is continuing to reshape industrial R&D activity, redefine the mission of federal laboratories, and reduce the growth rate of university research programs.

The purpose of this chapter is to track these and other U.S. and international trends in S&T financial investment.

Chapter Organization

This chapter is divided into five parts. The first, "National Trends in R&D Expenditures," contains information on overall R&D funding trends by source of support, performing sector, and character of work (including national investment in basic research, applied research, and development).

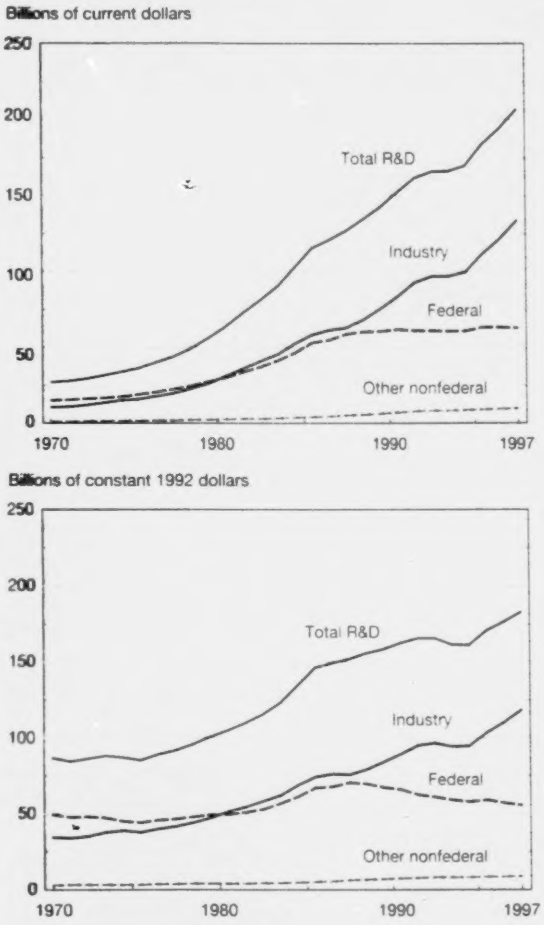
The second part, "R&D Patterns by Sector," takes a closer look at each of the R&D-performing sectors. R&D funding and performance by individual manufacturing and nonmanufacturing industries are examined; also included are discussions of R&D investment by size of company, R&D intensity, and federal support of industry-performed R&D. Next, the most recent data on federal R&D obligations are examined, including statistics for individual agencies and those classified by character of work. The part concludes with a discussion of federal laboratories' role in national R&D performance.

The third part is devoted to domestic partnerships and alliances within and between sectors. Topics covered include industrial R&D consortia, technology transfer activities, and other federal programs designed to stimulate joint research activities.

International R&D comparisons are examined in the fourth part, beginning with an analysis of absolute levels of total and nondefense spending by country, R&D/gross domestic product (GDP) ratios, patterns of sector-specific funding and performance, and information on the character of R&D work undertaken. Next, considerable detail on governments' R&D focus and priorities is provided, including a summary of recent policy initiatives and fiscal incentives for R&D performance.

The fifth part summarizes the growth of international R&D and technology alliances and the rapid rise in industrial R&D investment flows into and out of the United States.

Figure 4-1.
National R&D funding, by source



See appendix tables 4-5 and 4-6.

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National Trends in R&D Expenditures

R&D investment in the United States hit a record-setting high in 1997, reaching an estimated $205.7 billion. Total R&D expenditures climbed an average of 4.3 percent per year (in inflation-adjusted dollars) between 1994 and 1997, the highest rate of growth recorded since the early 1980s. In addition, R&D as a percentage of GDP has also been rising. The recent expansion in R&D investment marks a change from the late 1980s and early 1990s when there was relatively little or no real growth in overall R&D spending. (See figure 4-1 and appendix tables 4-3 and 4-4.)

National R&D Trends by Source of Support and Performing Sector

The two major sources of financial support for R&D are industry and the Federal Government, which together supply approximately 95 percent of all funds spent on R&D performed in the United States. The remaining 5 percent is provided primarily by universities and colleges and nonprofit organizations. (See figures 4-1 and 4-2 and appendix table 4-5.)

In addition to financing R&D, industry and the Federal Government are two of the three leading R&D-performing sectors. The third is academia, which is a distant second to industry in terms of R&D performance. In 1997, industry, academia, and the Federal Government were responsible for spending 74 percent, 12 percent, and 8 percent, respectively, of the total dollars invested in R&D in the United States. Two other groups—federally funded research and development centers (FFRDCs)[1] and nonprofit organizations—accounted for 4 percent and almost 3 percent, respectively.[2] (See figure 4-2 and appendix table 4-3.)

Industry's share of national R&D performance has been rising steadily—from two-thirds of the total in the 1970s to nearly three-fourths in the late 1990s. During the same period (1970-97), the academic share rose slightly—from 9-10

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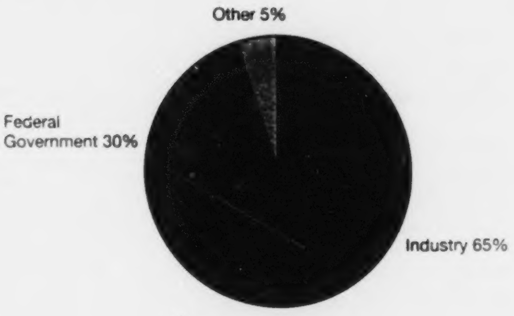
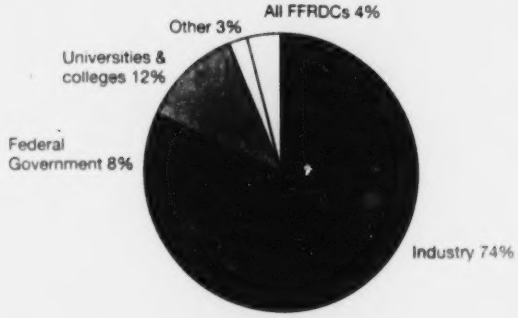
[1] FFRDCs are organizations exclusively or substantially financed by the Federal Government to meet particular requirements or to provide major facilities for research and associated training purposes. Each center is administered by an industrial firm, an individual university, a university consortia, or a nonprofit organization.

[2] R&D performed by state and local governments is not included in the national R&D totals. In 1995, R&D performance by these entities was estimated to be less than $400 million. (See "State R&D Issues: High Geographic Concentration and New Data on State Government R&D Support.")

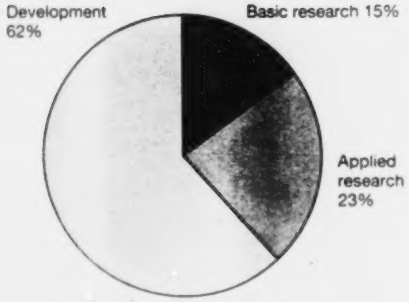
Figure 4-2.
National R&D expenditures: 1997



By source of funds



By performing sector



By character of work

NOTE: FFRDCs are federally funded research and development centers. See appendix tables 4-3, 4-5, 4-7, 4-11, and 4-15.

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percent to 12-13 percent—and the federal share dropped by half—from 16 percent to 8 percent.

Sources of R&D Support

For-profit companies are responsible for the current upswing in R&D investment in the United States. In addition to being both the largest source of R&D funds and the leading R&D-performing sector in the United States, industry also had the highest percentage increase in R&D investment in the mid-1990s.

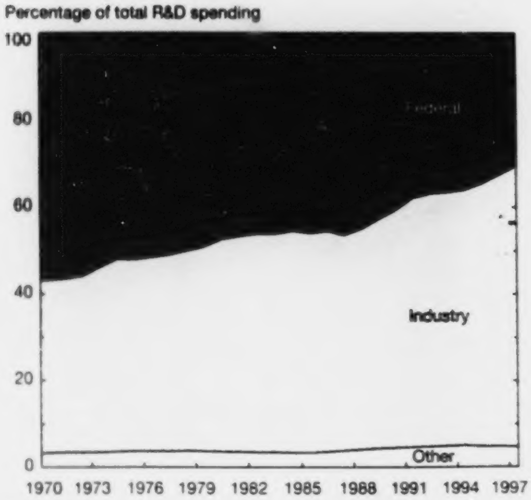
In 1997, companies provided an estimated $133.3 billion to finance R&D performed in the United States, or 65 percent of the national total. Nearly all of this amount—$130.6 billion—was spent on R&D conducted in industrial facilities; the remaining $2.7 billion was used to support R&D activities undertaken on university and college campuses and at other nonprofit organizations. (See appendix table 4-5 and text table 4-1.)

Industry-Supplied Funding on the Rise. In 1980, industry surpassed the Federal Government as the leading supplier of R&D dollars in the United States. (See figure 4-1.) During the early and mid-1980s, industry's share of the total stood at about 50 percent. Then, in 1987, the proportion of total industry-supplied R&D monies began an almost continuous decade-long climb, with the most recent data showing industrial firms providing $2 out of every $3 spent on R&D in the United States. (See figure 4-3.)

Between 1995 and 1997, industry R&D financing grew at an estimated average annual rate of 7.7 percent per year in inflation-adjusted dollars. This trend contrasts with that of the preceding three-year period 1991-94, when no real growth occurred in industry-supplied R&D dollars.

Federal R&D Funding in Decline. While industry's share of the national total was expanding, the federal share was shrinking. In 1997, the Federal Government provided an estimated $62.7 billion in R&D support, with federal agencies providing 30 percent of all monies spent on R&D in the United States, down from 46 percent a decade earlier (at the peak of the defense buildup). (See figure 4-3.) Federal R&D funding declined almost continuously in real terms between 1987 and

Figure 4-3.
National R&D expenditures, by source of funds



See appendix table 4-5 *Science & Engineering Indicators – 1998*

Text table 4-1.
U.S. R&D expenditures, by performing sector and source of funds: 1997
(Millions of U.S. dollars)

		Source of R&D funds				
R&D performer	Total	Industry	Federal Government	Universities and colleges[a]	Other nonprofit institutions	Percent distribution, performers
Total	205,742	133,308	62,745	6,278	3,411	100.0
Industry	151,418	130,631	20,787	–	–	73.6
Industry-administered FFRDCs[b]	2,273	–	2,273	–	–	1.1
Federal Government	16,450	–	16,450	–	–	8.0
Universities and colleges	24,031	1,710	14,285	6,278	1,759	11.7
University-administered FFRDCs	5,405	–	5,405	–	–	2.6
Other nonprofit institutions	5,520	967	2,900	–	1,653	2.7
Nonprofit-administered FFRDCs	644	–	644	–	–	0.3
Percent distribution, sources	100.0	64.8	30.5	3.1	1.7	

– = unknown, but assumed to be negligible; FFRDCs = federally funded research and development centers

NOTES: Data are estimated. Details may not add up to totals because of rounding.

[a] Includes an estimated $1.8 billion in state and local government funds provided to university and college performers.

[b] FFRDCs conduct R&D almost exclusively for use by the Federal Government. Expenditures for FFRDCs therefore are included in federal R&D support, although some nonfederal R&D support may be included.

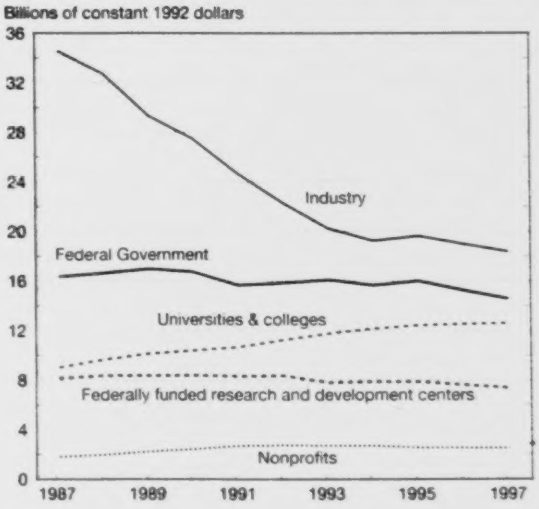
See appendix table 4-5. *Science & Engineering Indicators - 1998*

1997 at an average annual rate of 2.3 percent; the greatest drop occurred during the late 1980s and early 1990s. The descent seems to be tapering off, however, as the annual average decline was estimated to be only 1.3 percent between 1994 and 1997.

Most federal R&D dollars (74 percent) are not used in government-owned laboratories, but rather to finance R&D performed in other sectors. (See figure 4-4 and appendix table 4-5.) For example:

- ◆ Industry received an estimated $20.8 billion in federal R&D support in 1997 (one-third of all federal R&D monies), mainly to finance defense-related R&D performed under contract to the Departments of Defense (DOD) and Energy (DOE).
- ◆ Academic institutions acquired an estimated $14.3 billion in federal R&D support in 1997; almost all of the funds supported basic and applied research in the natural sciences and engineering. In addition to the acquisition of new knowledge and breakthrough discoveries, research conducted on university and college campuses provides another widely acknowledged benefit by playing a key role in training the next generation of scientists and engineers. (For more information, see chapters 2 and 5.)
- ◆ FFRDCs and other nonprofit organizations received an estimated $8.3 billion and $2.9 billion, respectively, in federal R&D funds in 1997.

Figure 4-4.
Federal R&D support, by performing sector



See appendix table 4-6. *Science & Engineering Indicators – 1998*

Declining Federal Support Felt Most by Industry. The decline in overall federal R&D funding is reflected in data for each of the R&D-performing sectors—except academia—but is most visible in data showing federal support of R&D performed by industry. During the period 1992-97, federal R&D funds supplied to industry are expected to show an average annual decline of 3.8 percent in constant 1992 dollars. Cutbacks in federal intramural and federal support to nonprofit organizations are expected to average 1.7 percent, and to all FFRDCs, 2.5 percent in constant 1992 dollars.

In 1987, federal R&D funds accounted for just under one-third of all monies spent by companies to conduct R&D. The most recent data show the shrinking of that proportion down to an unprecedented 14 percent. (It should be noted that the federal share of the industry total has been shrinking almost continuously since at least 1970, because industry's own funding has either outpaced or has not declined as rapidly as federal support.) Although defense downsizing seems to have taken a heavy toll on industry R&D, it is becoming increasingly difficult to track defense R&D flows from federal agencies to industry performers. (See "Accounting for Defense R&D: Discrepancies Between Performer- and Source-Reported Expenditures.")

The curtailment of federal R&D work has had a definite negative effect on overall industrial R&D performance numbers since 1987. That is, the estimated 6.1 percent average annual decline in federal R&D support in constant dollars registered between 1987 and 1997 partially offset growth in industry's own funding during the 10-year period. In 1997, federal support of industry-performed R&D was an estimated $20.8 billion, down about $8 billion from the level reported 10 years earlier. (See figure 4-5 and appendix table 4-3.)

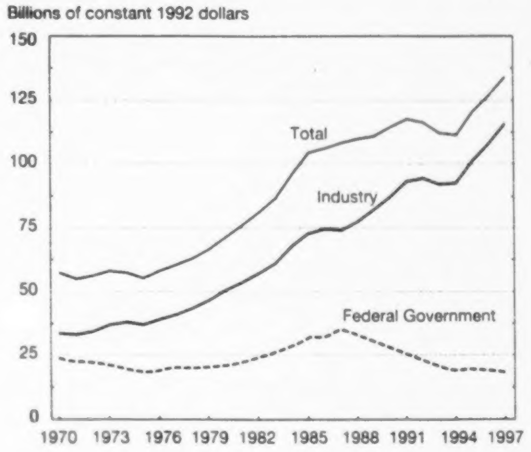
Annual Growth Rate Slowed for Academia. It is important to emphasize that the annual level of federal R&D support to academia has not declined. However, the annual rate of growth in federal support has been falling fairly steadily (in all but two of the past dozen years). The growth rate decline can be attributed to efforts to balance the budget and reduce the deficit. Although academia is the only R&D-performing sector not to have experienced a cutback in federal support during the 1990s, little real growth is expected for 1995-97. While the annual level of total R&D support supplied by each of the five sources that fund academic R&D rose in both current and constant dollars (see appendix tables 4-3 and 4-4), all the sources exhibited 1992-97 growth rates that were about half or less than half of those recorded for the previous five-year period.

Despite the recent slowing, federal support to universities and colleges is estimated to have increased at an average annual constant-dollar rate of 2.3 percent between 1992 and 1997. Industrial support is estimated to have had the largest percentage increase during that period (32 percent), but federal agencies registered the largest absolute increase ($3 billion) in support of academic R&D.

National R&D Trends by Performing Sector

Industry. In the United States, industry has always been the overwhelming leader in R&D performance. In 1997, three-fourths of the total amount spent on R&D performed in the United States financed work undertaken in industrial laboratories. The total cost of that work is estimated at more than $150 billion; federal agencies supplied approximately 14 percent of those funds. (See appendix table 4-3.)

Figure 4-5.
U.S. industrial R&D expenditures, by source of funds



See appendix table 4-4. *Science & Engineering Indicators – 1998*

A surge in industrial R&D performance during the mid-1990s saw annual expenditure increases estimated at 6.2 percent per year in inflation-adjusted dollars between 1994 and 1997—the highest rate recorded since the early 1980s. The expansion is entirely attributable to companies' own R&D investment and represents a turnaround from the preceding three-year period when the annual level of industrial R&D outlays failed to keep pace with inflation. (See figure 4-6 and appendix tables 4-3 and 4-4.)

Academia. Academia is a distant second to industry in terms of R&D performance, with total expenditures amounting to an estimated $24 billion, or 12 percent of the national total. Until 1989, the academic sector ranked third in total R&D performance in the United States, after industry and the Federal Government. Since 1983, however, the annual rate of increase in R&D performed at universities and colleges has been higher than that of the Federal Government (except in 1995). As a result, academic institutions moved into second place in 1989, behind industry. (See figure 4-6 and appendix table 4-3.)

Academia has not suffered a constant-dollar decline in R&D performance in more than two decades. (See appendix table 4-4.) However, the annual real rate of growth has been decreasing almost continuously since 1986, falling from a near 10 percent increase that year to an estimated 1 percent change in both 1996 and 1997.

Most of the research performed on university and college campuses is funded by the Federal Government. In 1997, federal agencies provided an estimated $14.3 billion, or about 60 percent of the total. Academic institutions supplied an estimated $4.5 billion of their own funds,[3] state and local governments and nonprofit organizations each contributed $1.8 billion, and industry provided $1.7 billion.

Federal R&D support to academia has been increasing continuously since 1982, even after adjustment for inflation. Although industry supplies fewer R&D dollars to universi-

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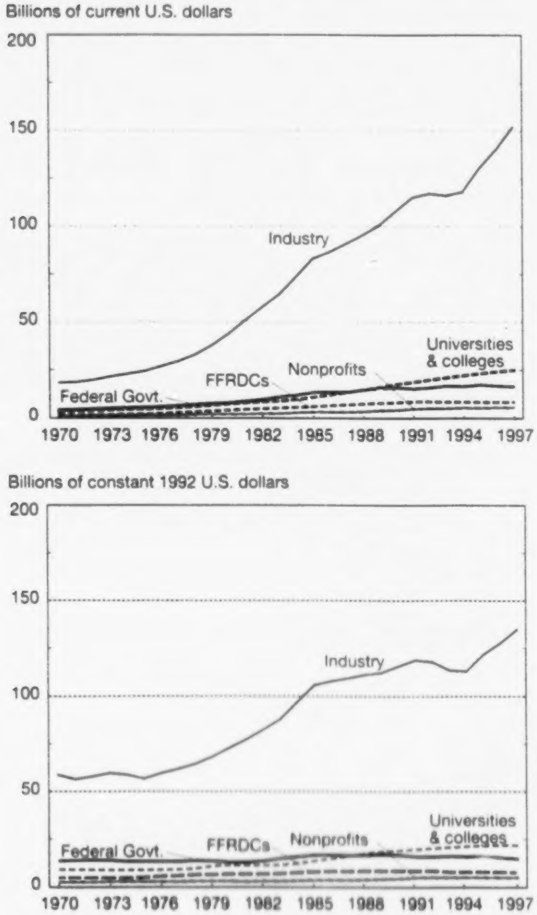
[3] See chapter 5, "Financial Resources for Academic R&D," for an explanation of universities' and colleges' "own funds" and for further discussion of academic R&D expenditure trends.

Figure 4-6.
National R&D funding, by performer



NOTE: FFRDCs are federally funded research and development centers. See appendix tables 4-3 and 4-4.

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ties and colleges compared to the other four sources, it has an even longer track record than the Federal Government of continuous growth in the support of academic research—stretching back to at least 1970. As a result, the proportion of academic R&D expenditures supplied by industry has been rising fairly steadily, although industry still represents only a fraction (7 percent) of total academic R&D support.

Federal Agencies. Federal entities spent an estimated $16.5 billion on intramural R&D in 1997. (Most federal R&D monies are not spent in federally run facilities, but in other sectors.) Federal intramural R&D, as a percentage of total national R&D performance, has been falling fairly steadily since the early 1970s and was down to an estimated 8 percent in 1997.

In real terms, federal intramural R&D is at its lowest point since 1982 because of cutbacks in DOD laboratories; these labs accounted for 56 percent of the intramural total in 1982, but less than half (48 percent) in 1997. The most recent data show an estimated constant-dollar decline of 9 percent between 1995 and 1997. (See figure 4-6 and appendix table 4-4.)

R&D Support and Performance by Character of Work

The traditional way to analyze trends in R&D performance is to examine the amount of funds devoted to basic research, applied research, and development. (See "Definitions.") These terms are convenient because they correspond to popular models that depict innovation occurring in a straight-line progression through three stages: (1) scientific breakthroughs from

Definitions

The National Science Foundation uses the following definitions in its resource surveys. They have been in place for several decades and are also generally consistent with international definitions.

Basic research. The objective of basic research is to gain more comprehensive knowledge or understanding of the subject under study, without specific applications in mind. In industry, basic research is defined as research that advances scientific knowledge but does not have specific immediate commercial objectives, although it may be in fields of present or potential commercial interest.

Applied research. Applied research is aimed at gaining the knowledge or understanding to meet a specific, recognized need. In industry, applied research includes investigations oriented to discovering new scientific knowledge that has specific commercial objectives with respect to products, processes, or services.

Development. Development is the systematic use of the knowledge or understanding gained from research directed toward the production of useful materials, devices, systems, or methods, including the design and development of prototypes and processes.

Budget authority. Budget authority is the authority provided by federal law to incur financial obligations that will result in outlays.

Obligations. Federal obligations represent the amounts for orders placed, contracts awarded, services received, and similar transactions during a given period, regardless of when funds were appropriated or payment required.

Outlays. Federal outlays represent the amounts for checks issued and cash payments made during a given period, regardless of when funds were appropriated or obligated.

R&D plant. Federal obligations for R&D plant include the acquisition of, construction of, major repairs to, or alterations in structures, works, equipment, facilities, or land for use in R&D activities at federal or nonfederal installations.

the performance of basic research (2) lead to applied research, which (3) leads to development or application of applied research to commercial products, processes, and services.

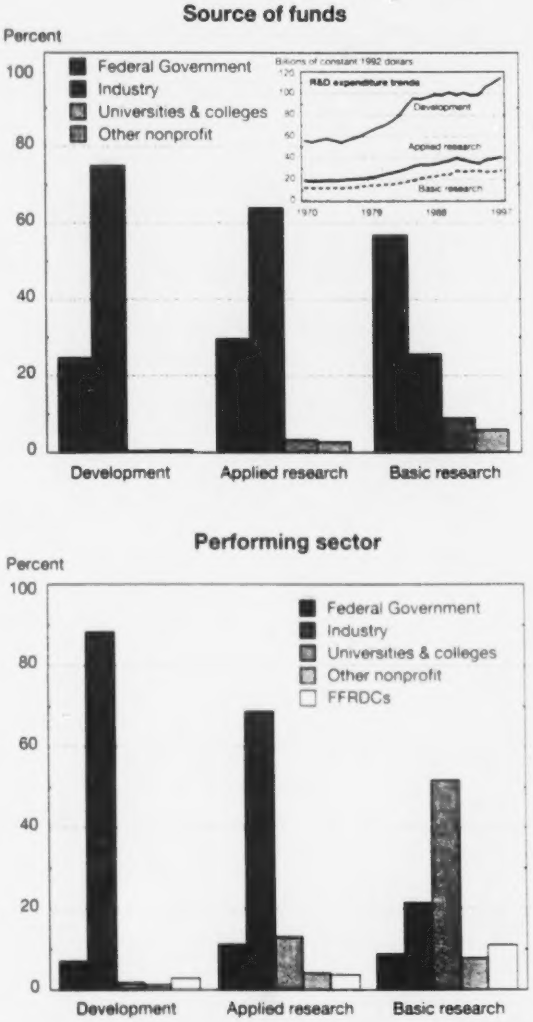
The simplicity of this approach makes it appealing to policymakers, even though the traditional categories of basic research, applied research, and development do not always ideally describe the complexity of the relationship between science, technology, and innovation in the real world.[4]

Alternative and perhaps more realistic models of the innovation process have been developed, but they are probably too complicated to be used in collecting and analyzing comparable and reliable data for policymaking purposes, and would not enable time-series analyses. Therefore, the practice of categorizing R&D expenditures into basic research, applied research, and development is unlikely to be abandoned anytime soon.

All three categories of R&D funding contributed to the overall growth in R&D spending in the United States in the mid-1990s, and all three were at their highest levels ever recorded in both current and constant dollars. (See figure 4-7.) All of the gains, however, took place in the private sector. In terms of R&D financial support, the Federal Government's share of total funding for applied research and development dropped dramatically between 1987 and 1997. For applied research, the proportion declined from 38 to 29 percent. The development loss was even more steep, falling from 46 percent of the total to 25 percent. The Federal Government's share of basic research funding also fell during the same 10-year period—from 61 percent of the total to 57 percent. (See figure 4-8.)

Most R&D dollars—an estimated $128.3 billion in 1997, or 62 percent of the total—are spent on development. Applied research accounted for an estimated 22.5 percent, and basic research for 15 percent. These proportions tend to be fairly stable over time, although percentage point changes usually occur from year to year. For example, basic research's proportion of total R&D varied from 13 to 17 percent during the last quarter century, while applied research and development ranged from 22 to 24 percent, and from 60 to 65 percent, respectively. In the mid-1990s, development increased a couple of percentage points, and basic research fell by about the same amount—probably a reflection of the expanding role of industry in national R&D performance. Industry performs relatively more development and less basic research than the other sectors.

Figure 4-7.
National R&D expenditures, by source of funds, performing sector, and character of work: 1997



NOTE: FFRDCs are federally funded research and development centers.
See appendix tables 4-3, 4-5, 4-7, 4-9, 4-10, 4-11, 4-12, 4-13, 4-14, 4-15, and 4-18.

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Basic Research

In 1997, an estimated $31.2 billion was spent on basic research performed in the United States, an increase of about 4 percent in real terms over the 1995 level, and somewhat below the overall R&D increase of 7 percent during the two-year pe-

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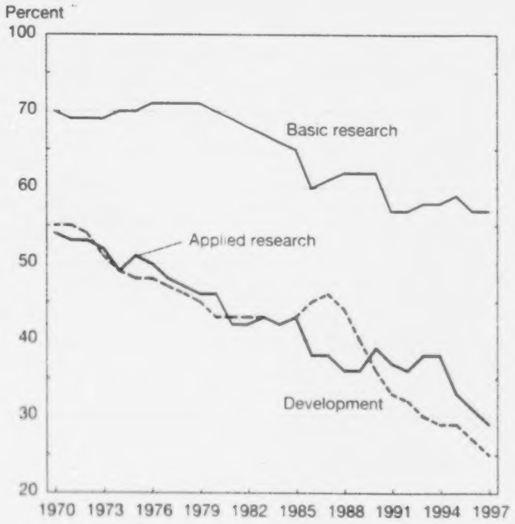
[4] See NSB (1996), chapter 4, "Alternative Models of R&D and Innovation." In a recent report, the Council on Competitiveness (1996) said "the old distinction between basic and applied research has proven politically unproductive and no longer reflects the realities of the innovation process… The United States [should adopt] a new and more up-to-date vocabulary, one that accounts for changing calculations of R&D risk and relevance over short-, medium- and long-term horizons." In its report, the Council identified three types of research (short-term/low-risk, mid-term/mid-risk, and long-term/high-risk) and the economic sectors that have primary and secondary responsibility for each.

In contrast, another recent study found that R&D managers/directors and financial officials/accountants in both manufacturing and nonmanufacturing firms generally agree that the National Science Foundation's classification of R&D expenditures into basic research, applied research, and development appropriately describes the scope of their companies' self-financed R&D activities (Link 1996a).

Figure 4-8.
The federal share of total U.S. funding of basic research, applied research, and development



See appendix tables 4-5, 4-9, 4-13, and 4-17.

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riod. Most of that amount—$17.7 billion, or 57 percent of the total—was supplied by the Federal Government. Industrial firms provided $8 billion, or 25 percent of the total; universities and colleges, $2.7 billion; and nonprofit organizations, $1.7 billion.[5] (See figure 4-7 and appendix table 4-9.)

Academic Sector Performance. Although the Federal Government is the leading supplier of funds, the academic sector is the largest performer of basic research, with expenditures totaling an estimated $16 billion in 1997. Of that amount, $10 billion were federal funds. Far smaller amounts were supplied by the universities themselves, and by state and local governments, industry, and nonprofit organizations. (See appendix table 4-7.)

Financial support for basic research performed in the academic sector is not growing as fast as it did in the late 1980s and early 1990s. The average annual constant-dollar rate of growth was an estimated 2.3 percent between 1992 and 1997, down from the 4.4 percent average registered during the preceding five-year period. All five funding sources contributed to the slowdown, each exhibiting a lower rate during the period 1992-97 than during 1987-92. The drop is particularly noticeable in the largest source of funding—the Federal Government. It is estimated that between 1995 and 1997, federal funding of basic research performed in the academic sector barely kept pace with inflation. (See appendix table 4-10.)

Industry's support of research conducted on university and college campuses has always been a small but growing component of the academic research portfolio. Industry officials have tapped this resource not only to realize the beneficial results of the research they sponsor, but also to capitalize on opportunities to train future scientists and engineers, most of whom will one day be working in their laboratories.[6] Industrial support can take a number of forms, including hiring professors as consultants, funding postdoctoral joint research, and/or providing grants to individual departments (Council on Competitiveness 1996). Although only a small fraction of academic basic research is financed by industry—an estimated 6.5 percent in 1997—companies' support increased an estimated 8 percent in real terms between 1995 and 1997, the largest percentage gain of the five sources that fund academic basic research.[7]

Increasing use is being made of university research to fill gaps left when industrial basic research is curtailed, e.g., industry and university personnel have been collaborating in areas of military importance, including lasers, electronics, computing, and materials (U.S. DOD 1996). Results from an annual Industrial Research Institute survey confirm that "industry is depending more and more on academic research," e.g., the percentage of respondents anticipating increasing grants for academic R&D rose from 12 percent in 1993 to more than 20 percent in 1996 and 1998 (IRI 1997).

Industrial Performance. Industrial firms spent an estimated $6.6 billion in company and federal funds on basic research in 1997—about 4 percent of all industrial R&D expenditures. The vast majority of these funds were companies' own financial resources, which increased an estimated 14.5 percent in real terms between 1995 and 1997. (See appendix tables 4-7 and 4-8.)

The gain in industrial investment in basic research estimated for 1995-97 partially offsets a 20 percent decline that took place during the preceding four-year period when several companies' central research facilities were dismantled. That period marked the beginning of a trend toward shorter term R&D and away from fundamental research, largely "driven by the competitive environment and a motivation to extract greater value (or 'effectiveness') from R&D investments" (Larson 1997b). (See "Top 10 'Biggest' Problems for Technology Leaders.") R&D is increasingly being conducted within individual business units in a concerted effort to speed

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[5] According to a recent study, only around 2 percent of basic research performed in the United States is supported by foreign sources (Cahners Research 1997).

[6] A recent study revealed that automotive industry officials are more interested in universities' preparation of students than in the usefulness of the research their companies fund. Although they praised the schools for an increased emphasis on manufacturing, they also felt "graduate programs needed to focus more on real-world concerns" (Council on Competitiveness 1996).

[7] Passage of the University and Small Business Patent Procedure Act of 1980, better known as the "Bayh-Dole Act," (see text table 4-8) spurred a major increase in research collaborations between academia and industry.

Top 10 "Biggest" Problems for Technology Leaders

The Industrial Research Institute has been surveying its membership annually since 1993 to identify the biggest problems for technology leaders. (See text table 4-2.) Results from the 1997 survey rank "managing R&D for business growth" first; this issue has increased in relative importance to the Institute's members, who ranked it fourth and fifth in 1996 and 1995, respectively. "Balancing long-term/short-term R&D objectives/focus" was identified as the second most important problem every year of the survey except 1996 (where it ranked first) and 1993 (third). "Integration of technology planning with business strategy" ranked third in three of the five years. The only item evidencing a noticeable decline in relative importance over the five-year period was "measuring and improving R&D productivity/effectiveness." Until 1996, this item was ranked first in importance; in 1996, it fell to second; and in 1997, it was ranked seventh out of the 10 problem areas.

Text table 4-2.
Top 10 "biggest" problems for technology leaders
(Percentages of total votes)

Survey item	1993	1994	1995	1996	1997
Number of total responses	248	193	258	242	223
Managing R&D for business growth	NA	NA	5.9	10.0	17.0
Balancing long-term/short-term R&D objectives/focus	10.1	12.2	11.0	12.1	14.7
Integration of technology planning with business strategy	11.0	10.2	7.4	11.2	13.0
Making innovation happen	NA	NA	7.8	9.5	10.3
Management of global R&D	3.8	2.9	3.5	4.5	5.8
Leadership of R&D within the corporation	1.7	3.2	2.3	4.2	4.0
Measuring and improving R&D productivity/effectiveness	15.2	15.1	11.5	11.8	4.0
R&D portfolio management	4.2	5.0	4.5	4.5	4.0
Selling R&D internally or externally	5.0	3.1	2.6	4.2	4.0
Information technology	NA	NA	NA	NA	3.1
Percent of responses (top 10)	40.9	39.5	56.5	72.0	79.9

NA = not asked

SOURCE: Industrial Research Institute, Member Company Representatives, "The 'Biggest' Problems Technology Leaders Face," *Research Technology Management*, September-October, 1997.

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commercialization of new technology.[8] Company research is being "driven largely by business needs rather than curiosity" (Larson 1997b).

In some companies, corporate support for "central research" activity has been eliminated completely. Allied Signal, Armstrong World Industries, and W.R. Grace are recent examples (Larson 1997b). A survey of leading firms found that central corporate funding accounted for about 50 percent of central laboratories' budgets in 1988, but had fallen to about 40 percent in 1993, and that the percentage of corporate funding in the budgets of business unit laboratories decreased from almost 40 percent to less than 10 percent during the same period (Bean 1995). According to another study, increases in outlays for applied research and development have occurred at the expense of basic research (Cahners 1997).

Federal Intramural Performance. An estimated $2.7 billion was used to finance basic research performed in federally run laboratories in 1997. The annual level of funding has not changed appreciably in real terms since the early 1980s. (See appendix table 4-8.) In addition, basic research as a percentage of total federal intramural research has held constant (at 15 to 16 percent) for the past two decades, indicating that applied research and development—not basic research—have felt the brunt of the general overall decline in federal intramural research.

Applied Research

An estimated $46.2 billion was spent on applied research performed in the United States in 1997—22.5 percent of the national R&D total. The annual level of investment in applied research increased an estimated 17 percent in real terms between 1994 and 1997, more than offsetting a brief 12 percent downward slide that occurred during the preceding three-year period. (See figure 4-7 and appendix table 4-12.)

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[8] In the late 1980s and early 1990s, U.S. industrial firms were forced to react to a significantly changed climate for R&D financing. Product development was becoming increasingly market- rather than technology-driven, and profit margins were eroding because of escalating international competition and ever-shortening product life cycles. To survive, companies had to cut costs and take a shorter term, more product-oriented approach to R&D. (See "Top 10 'Biggest' Problems for Technology Leaders.") To meet these challenges, many corporate central research laboratories were either eliminated or downsized, and business units took on a more prominent role in performing and funding R&D. In addition, outsourcing R&D to other companies and organizations became a popular way of keeping costs under control. The benefits of these changes are reflected in the enhanced competitiveness of U.S. companies in the mid-1990s. Not only has the conversion of R&D results into new products, processes, and services been accelerated, but the United States has strengthened its position in several critical technologies in which it had been slipping (Council on Competitiveness 1996).

Industry, which led the growth in investment in applied research in the mid-1990s, is both the leading supporter and performer of this type of research. (See figure 4-7 and appendix table 4-13.) In 1997, companies were the source of an estimated $29.4 billion spent on applied research undertaken in the United States, up 36 percent in real terms over the 1994 level. In general, the proportion of all applied research funds originating in industry has been increasing steadily—up from 42 percent of the national total in 1970 to 64 percent estimated for 1997. Industry's *performance* of applied research was at an all-time high in 1997, an estimated $31.7 billion (in current dollars), or 69 percent of the national total.

The industrial increase in applied research performance is noteworthy on two counts. First, it represents a major turnaround from the early 1990s when, between 1991 and 1994, the annual number of dollars invested in applied research conducted in industrial laboratories dropped more than $1 billion per year. Second, it is entirely attributable to companies' own investment. After a series of hefty increases in federal funding of industry-performed applied research in the early 1980s, the level fell each year between 1985 and 1988, recovering in the late 1980s only to decline again in the 1990s. In 1997, federal support of industry-performed applied research was just over half the level recorded seven years earlier. (See appendix table 4-11.)

While industry financing of applied research was recovering from an early 1990s slump, federal funding continued to slide downward, falling an estimated 12 percent in real terms between 1993 and 1997. The Federal Government's share of the total has been declining since 1970, falling from 54 percent that year to an estimated 29 percent in 1997. The decline was particularly steep during the recent period 1994-97, with a drop of 9 percentage points.

Between 1994 and 1997, a major disparity marked trends occurring among the three leading R&D-performing sectors. While the annual level of spending on applied research undertaken in industrial laboratories rose a healthy 28 percent in constant 1992 dollars, the amount spent by academic institutions increased by a modest 5 percent, and the Federal Government's intramural performance was off by about 6 percent. (See appendix table 4-12.)

The annual level of federal investment in intramural applied research held steady in the mid-1990s at approximately $5 billion; therefore, only a slight reduction in real dollars took place between 1994 and 1997. In contrast, during the preceding six-year period, federal intramural applied research outlays increased an average of 3.4 percent per year in constant dollars. (See appendix tables 4-11 and 4-12.)

Development

Six out of every 10 dollars spent on R&D in the United States are spent on development. (See figure 4-7 and appendix tables 4-3 and 4-15.) An estimated $128.3 billion was used to finance the development of new and improved products, processes, and services in 1997. This amount exceeds the 1995 level by about 8 percent, after adjustment for inflation. Development funding has been increasing in real terms since 1993, offsetting sluggish growth in the late 1980s and a brief downward trend in the early 1990s which reflected defense spending cutbacks following the end of the Cold War. Federal support of development projects has been falling in real terms since 1987 at an average annual rate of 4.5 percent, although the rate of decline slowed in the most recent years. In contrast, industry financing increased 5.1 percent per year during the decade. (See appendix table 4-18.)

As with applied research, industry is both the leading provider of development funds and the major performer. Industry became the largest source of development funds in 1974, overtaking the Federal Government that year. Because the advancing and applying of new technologies are activities undertaken almost exclusively in the private, for-profit sector, almost all development dollars (nearly 90 percent) are spent by industrial firms. In 1997, industrial firms were the source of an estimated $95.9 billion, or about 75 percent, of the total spent on development in the United States. All but $313 million of these funds were spent in industrial laboratories. The federally provided share of development funds is now estimated to be 25 percent of the total, down from more than 40 percent during the late 1970s and 1980s. (See figure 4-8 and appendix table 4-17.)

Of the estimated $113 billion spent by industry on development in 1997, an estimated $17.5 billion, or 15 percent of the total, came from federal contracts. Since 1987, a major curtailment in the annual level of federal funding was reported by industry, with a 27 percent (47 percent after adjustment for inflation) drop being registered between 1987 and 1997. (See appendix tables 4-15 and 4-16.) The most recent data show the other R&D-performing sectors—including the Federal Government, universities and colleges, nonprofit organizations, and FFRDCs—responsible for spending only 12 percent of the national total.

As development R&D *performers*, federal agencies spent an estimated $8.7 billion in 1997, placing the Federal Government a distant second to industry in terms of development performance. The most recent data show the annual level at about $1 billion below the 1990 level. In real terms, federal intramural performance of development fell at an average annual rate of 3.7 percent between 1989 and 1997.

R&D Patterns by Sector

In this part, industry and Federal Government investment in R&D is examined in greater detail. See chapter 5 for additional information pertaining to R&D performance in the academic sector.

Industrial Research and Development

Industry is, by far, the largest R&D-performing sector. In 1997, for-profit companies spent an estimated $130.6 billion of their own (and otber nonfederal) funds and $20.8 billion in federal funds on R&D performed in U.S. industrial labs.

(See figure 4-6 and appendix table 4-3.) In addition, an estimated $2.3 billion in federal funds were spent on R&D performed at FFRDCs administered by industrial firms.

Mid-1990s Expansion. Between 1993 and 1997, companies' own spending grew at an average annual rate of 5.8 percent in inflation-adjusted dollars. This mid-1990s expansion in industrial R&D activity is largely attributable to international competition; sustained, record-setting profitability; and the introduction of new capabilities in information technology. In addition, in many firms, external research funding is growing at a rate faster than internal spending (Larson 1997b). (See "External Sources of Technology Gaining in Popularity.") The most recent National Science Foundation (NSF) data show a 43 percent increase in company R&D funds contracted to outside organizations between 1994 and 1995 (NSF 1997a).

The recent upswing presents a sharp contrast to the preceding two-year period when R&D financing was relatively flat. In addition, the 1993-97 increase exceeds the 4.2 percent average annual gain recorded between 1985 and 1991.

Federal Government Share at All-Time Low. There was a time (30 years ago) when the Federal Government contributed more than half the total amount of funds spent by industry on R&D activities. Although those days are long gone, government funding did account for one-fourth to one-third of all industry R&D spending as recently as the late 1980s. (See figure 4-5.) The most recent data, however, show that proportion, at 14 percent, to be the lowest it has ever been—12 percentage points below what it was in 1989. Between 1987 and 1997, federal funding of industry-performed R&D fell at an average annual constant-dollar rate of 6.1 percent. However, the descent seems to be slowing: the estimated average yearly rate of decline for 1994-97 is less than it was earlier in the decade. (See appendix table 4-4.)

R&D in Manufacturing Versus Nonmanufacturing Industries

Probably the most striking change in industrial R&D performance during the past decade is the service sector's increased prominence. Until the late 1980s, little attention was paid to R&D conducted by nonmanufacturing companies, largely because service sector R&D activity was negligible compared to the R&D operations of companies classified in manufacturing industries.

External Sources of Technology Gaining in Popularity

There are a number of ways companies can access external sources of technology, including:

- outright acquisition,
- exclusive license,
- joint venture,
- minority equity,
- option for future license,
- joint development,
- R&D contract, and
- exploratory research funding (Chatterji 1996).

Although data on the number and value of these activities are largely unavailable, considerable anecdotal evidence indicates that outsourcing R&D is increasing. For example, aircraft manufacturers are outsourcing more of their R&D to their suppliers, subcontractors, and even customers;* they are also actively involved in joint ventures with their European counterparts (Council on Competitiveness 1996).

A number of factors make external sources of technology increasingly attractive. On the demand side are the following:

- Increased global competition has meant shorter product life cycles and faster development cycle time. To keep up with the accelerating pace of innovation, companies are increasingly having to look beyond their doors to gain access to new sources of technology.
- Downsized companies that handed out pink slips to many of their R&D professionals to reduce costs now find themselves without all the technical expertise they need.
- Collaboration enables participating companies to reduce their risks in exploring promising but highly speculative new technologies.
- Recent success stories have generated more interest in collaboration.

On the supply side, the following factors apply:

- The worldwide growth of scientific and engineering knowledge has created new, valuable—and available—information sources.
- The availability of venture capital has spurred the formation of startup companies in several high-tech areas, including biotechnology, electronics, and software, that are attractive sources of new technology.
- There is a growing workforce of technical professionals displaced by downsizing; their former employers and other organizations are eager to take advantage of their expertise and experience.

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*Boeing outsourced a significant amount of R&D connected with the development of its 777 airliner, including relying on foreign firms (the Japan Aircraft Development Corporation and other firms from Asia, Europe, and Canada) for design and manufacturing expertise (Council on Competitiveness 1996).

Increase in Service Sector R&D. Prior to 1983, nonmanufacturing industries accounted for less than 5 percent of the industry R&D total. A decade later, the R&D landscape looked very different because of a ninefold increase in service sector R&D. The proportion of total industrial R&D performed by companies classified in service industries reached 26 percent in 1993 and then decreased a couple of percentage points in 1994 and 1995. (See chapter 6, figure 6-15.)

In 1995, nonmanufacturing firms' R&D outlays totaled $32 billion—$27.4 billion in funds provided by companies and other nonfederal sources, and $4.6 billion in federal funds. (See appendix table 4-19.) Data for 1991-95 show the R&D expenditures of companies classified in the service sector increasing at about the same pace as in manufacturing companies (which accounts for the 2-point decline mentioned in the preceding paragraph).

Four industry groupings account for 90 percent of the nonfederal R&D performed in the service sector:

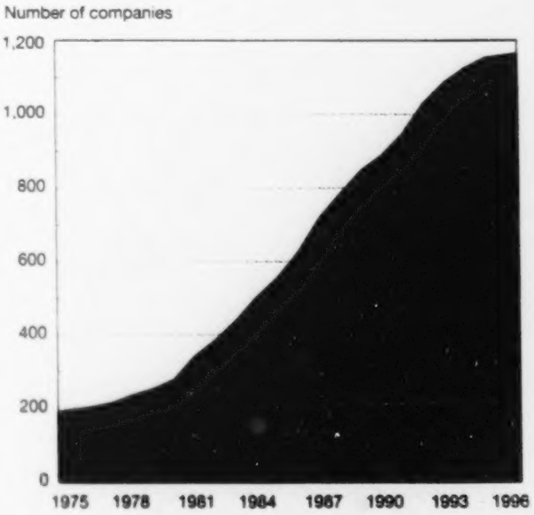
- computer programming, data processing, other computer-related engineering, architectural, and surveying services accounted for $9.6 billion in nonfederal R&D expenditures in 1995;
- wholesale retail trade, $7.5 billion;
- communications services, $4.8 billion; and
- research, development, and testing services, $2.8 billion.

It is likely that companies formerly classified in manufacturing industries account for a sizable portion of the R&D dollars in these service sector categories (especially the top three). For example, given the growing importance of computer software (relative to hardware) and other information technologies, a classification shift from manufacturing to nonmanufacturing would not be unusual.

In addition, because the United States invests a relatively large share of its resources in health care—13.6 percent of GDP in 1995 (U.S. HHS 1996)—the increasing importance of R&D laboratories in the nation's industrial R&D portfolio is also predictable. This greater prominence can be attributed, in large part, to major advances in research on the human body, the establishment and growth of a variety of medical research facilities, and the maturing and success of the biotechnology industry. For example, between 1975 and 1996, nearly 1,000 biotechnology companies came into existence.[9] (See figure 4-9.) Many of these companies are classified in the research, development, and testing services category.

The nonmanufacturing categories also contain a significant number of small startup firms. Some of these are spinoffs from academic research—which is how many software and biotechnology companies came into being (Council on Competitiveness 1996).

Figure 4-9.
Number of U.S. biotechnology companies



SOURCE: Institute for Biotechnology Information, U.S. Companies Database (Research Triangle Park, NC: 1997).

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Manufacturing Sector. As service sector R&D became more visible, manufacturing R&D lost some of its prominence. Nevertheless, the manufacturing sector continues to dominate industrial R&D. (See text table 4-3.)

In 1995, the six largest manufacturing industries—in terms of companies' own (and other nonfederal) R&D expenditures in the United States were:

Text table 4-3.
Share of total company and other nonfederal funds, by selected R&D-performing industries
(Percentages)

	1987	1991	1995
All manufacturing industries	91.6	74.7	74.8
Chemicals and allied products	15.4	15.9	16.0
Petroleum refining and extraction	3.1	2.7	1.6
Machinery	17.2	15.1	8.9
Electrical equipment	17.0	9.8	15.7
Transportation equipment	21.9	16.4	17.8
Instruments	8.1	7.6	7.8
All nonmanufacturing industries	8.4	25.3	25.2
Communication services	1.8	4.6	4.4
Wholesale/retail trade	NA	NA	6.9
Computer programming and other related services	3.6	3.6	8.8
Research, development, and testing services	0.1	NA	2.6

NA = not available

See appendix table 4-21.

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[9] In addition to 1,165 "pure" biotechnology companies (the vast majority of which came into being between 1975 and 1996), the Institute for Biotechnology Information counts 234 (including 56 instrument, 48 pharmaceutical, 32 chemical, 28 agricultural, 22 diagnostic, 20 food, 13 waste and environmental, and 15 in other categories) companies that also conduct biotechnology research.

- transportation equipment, $19.3 billion;
- chemicals and allied products (which includes the drugs and medicines industry), $17.3 billion;
- electrical equipment, $17.1 billion;
- machinery (which includes companies classified as computer hardware manufacturers), $9.7 billion;
- professional and scientific instruments, $8.5 billion; and
- petroleum refining and extraction, $1.8 billion.

These six industries accounted for 91 percent of all nonfederal R&D funds spent by companies classified in manufacturing industries in 1995, the same percentage they have held since at least 1985. What has changed is their share of all industrial R&D dollars. That proportion fell from over four-fifths of the total in 1987 to two-thirds in 1991, where it has remained. (See appendix table 4-21 and text table 4-3.)

Among the six industries, companies classified in the electrical equipment industry exhibited both the largest absolute increase ($8.2 billion) and the highest percentage increase (92 percent) in nonfederal R&D expenditures between 1991 and 1995. Text table 4-3 shows a flip-flopping in proportionate share of the total for the electrical equipment and machinery industries between 1991 and 1995, with the latter losing 29 percent of its nonfederal R&D monies. (All of the cutback was in the computer segment of the industry.)

It is probably safe to assume that some part of the machinery industry's decline is attributable to a reclassification of companies into other manufacturing (e.g., electrical equipment) and nonmanufacturing (software) industries, although this scenario cannot be confirmed.[10] Likewise, the electrical equipment industry's increase may reflect some movement of companies into that industry rather than real gains in R&D investment. However, further study of NSF survey data indicates that a sizable portion of the growth is real (NSF 1998c).

All of the additional electrical equipment industry monies appear in the electronic components segment, which accounted for 56 percent of that industry's 1995 R&D dollars and whose R&D spending increased threefold between 1991 and 1995.[11] Until 1993, the communications equipment segment was the largest component of the electrical equipment industry in terms of R&D. But in 1995, that segment's R&D expenditures were less than half those of electronic components companies; undoubtedly, some of the communications equipment decline reflects a reclassification of those firms into the nonmanufacturing communication services category. (See appendix table 4-21.)

In the largest R&D-performing industry—transportation equipment—a 7.9 percent average annual increase (in inflation-adjusted dollars) in R&D outlays by companies classified in the motor vehicles subgroup was somewhat offset by a 2.7 percent average annual decline in the aircraft and missiles segment between 1991 and 1995.[12] The 1991-95 increase in automakers' R&D financing represents a major acceleration in R&D investment by that industry, compared to the preceding six-year period. (See appendix table 4-21.)

It is no secret that U.S. companies' share of the world market for motor vehicles declined during the last quarter century; however, the industry has rebounded in recent years. The success and strength of foreign competitors actually led to a "revolution" of sorts in U.S. laboratories and production facilities. R&D has played a major role in the changes, in terms of both the automobile production process and the product itself.[13] The overriding goal of the changes has been to reduce production costs and time-to-market. Success is evident: where it once took five or more years for a new car to go from drawing board to showroom, it now takes only two to three years (Council on Competitiveness 1996).

Two of the largest R&D-performing industries—petroleum refining and extraction, and chemicals (excluding drugs and medicines)—did not contribute to the overall growth in nonfederal industrial R&D expenditures between 1991 and 1995.[14] Companies in these two industry classifications reported cutbacks of 29 percent and 5 percent, respectively, in their R&D financing during the period. (See appendix table 4-21.) R&D downsizing is reflected in oil and chemical companies' drop in ranking in *Inside R&D*'s annual list of the top 100 R&D performers in the United States. (See appendix table 4-23.) It is possible that at least some of the decline in in-house R&D reported by companies in these two industries is being offset by their increasing participation in industrial R&D consortia. (See "Industrial R&D Consortia.") Chemicals and petroleum companies are some of the most active members of research joint ventures (RJVs), especially those devoted to environmental R&D (Link 1996b).

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[10] The R&D cutback by computer hardware firms also reflects the industrywide trend of pulling back on central laboratory research to concentrate R&D resources on the development of new products for the marketplace (Council on Competitiveness 1996).

[11] According to the Council on Competitiveness (1996), "semiconductors, opto-electronics, and flat panel displays (FPD) are the three critical building blocks of electronics systems expected to drive U.S. competitiveness in electronics markets over the next several decades." Although the United States regained the lead in the global semiconductor market in 1992, Japan is still out-distancing the United States in FPD technology, opto-electronics, and photo-lithography.

[12] U.S. firms are no longer the sole players in the world's commercial aircraft market. In addition to the entry of Airbus Industrie Groupe (a consortium sponsored by the German, French, British, and Spanish governments), other nations (including Japan, China, Russia, and Taiwan) have announced their intentions to enter the commercial aircraft market (Council on Competitiveness 1996).

[13] For example, all U.S. firms have adopted Japanese manufacturing practices such as concurrent engineering. In addition, various computer and information technologies have improved and accelerated the design, development, and production of motor vehicles. Computer-based technologies have also played a major role on the product side, i.e., electronic systems have revolutionized the way vehicles are operated. In large part, these new capabilities reflect manufacturers' compliance with government regulations. Meeting standards for mileage, emissions, and safety has played a major role in shaping manufacturers' research agendas (Council on Competitiveness 1996).

[14] According to chemicals industry officials, long-term R&D—i.e., the development of new processes and products—has been sacrificed in favor of seeking incremental improvements for existing products. Until the 1980s, one-third to one-half of R&D expenditures in the industry went to new processes and products; that proportion is now down to less than one-fourth (Council on Competitiveness 1996).

In contrast to the lackluster R&D performance of industrial chemicals companies, the other part of the chemicals industry, which consists of pharmaceutical companies, had its usual healthy increase in R&D spending: the size of drug companies' R&D programs nearly tripled between 1985 and 1995.[15] (See appendix table 4-21.)

The most prominent recent trend in the drugs and medicines industry has been the melding of pharmaceutical and biotechnology research; more than one-third of drug companies' R&D projects are primarily biotechnology-related. In addition, pharmaceutical companies have been collaborating with and acquiring biotechnology companies to take advantage of the latter's potentially lucrative discoveries. The success and strength of the biotechnology industry is reinforcing the United States's world leadership position in drug research (Council on Competitiveness 1996).

R&D Expenditures by Size of Company

In 1995, 122 companies with more than 25,000 employees spent more than $1 million each on R&D in the United States (NSF 1998c). Prior to 1990, this group of companies accounted for more than half the nonfederal R&D expenditure total. That share has fallen below 50 percent because the R&D outlays of small and medium-size firms have been increasing faster than those of large companies. For example, small firms (those with fewer than 500 employees) accounted for 14 percent of all nonfederal R&D expenditures in the United States in 1995, up from 10 percent five years earlier. (See appendix table 4-21.)

Industrial R&D Concentrated in Large Firms. Despite small companies' rising share, U.S. industrial R&D expenditures remain heavily concentrated in a relatively small number of relatively large firms. For example, approximately 25 U.S. companies spent more than $1 billion each on R&D in 1996; 10 years earlier, only 10 companies exceeded the billion-dollar mark (Technical Insights 1997 and 1988). In 1995, the 4 largest R&D-performing companies (in terms of nonfederal funds) accounted for 16 percent of the total amount spent; the 20 largest, 34 percent; and the 200 largest, 68 percent. The last statistic, however, is less than the 80 percent and 82 percent shares held in 1990 and 1985, respectively. (See appendix table 4-24.)

Changes in Rankings of Top 100 R&D Companies. During the 10-year period 1986-96, major membership changes occurred in *Inside R&D*'s annual list of 100 leading R&D-performing companies. (See appendix table 4-23.) The three largest R&D-performing companies, however, were the same in both years, although the second- and third-ranked companies switched places. That constant may be one of few revealed by comparing the lists from 1986 and 1996, as major changes in rankings occurred among the remaining 97 entries:

- The 5th, 8th, 9th, and 10th largest R&D-performing companies in 1996 were not among the top 10 in 1986.[16] Of these four companies, Intel made the largest leap, going from 46th to 9th place.
- Computer software and some computer hardware, pharmaceutical, and biotechnology firms are increasingly prominent R&D performers. Companies like Microsoft, Sun Microsystems, Inc., Amgen, Seagate Technology, Genentech, Compaq Computer, and Cisco Systems were not even on the list in 1986 and now rank in the top 50. Microsoft spends more on R&D than all but a dozen U.S. companies.
- Almost half the companies ranked 50 to 100 are new to the list. Nearly every company in the new group is either a software (e.g., Novell) or a biotechnology (e.g., Genzyme) company.
- Almost all petroleum and chemical companies fell sharply in rank. For example, Dupont dropped from 6th to 26th place, and Dow Chemical and Monsanto dropped from 15th and 17th, respectively, to 31st and 32nd. The largest oil company, Exxon, was 41st in 1996, compared to 14th 10 years earlier.
- Aerospace firms also declined in ranking. Boeing and McDonnell Douglas (which merged in 1997) dropped from 11th to 20th and from 19th to 55th, respectively. The combination of Lockheed and Martin Marietta and all the other acquisitions that now comprise a single company (see figure 4-10) kept Lockheed Martin at number 30.

R&D Intensity

In addition to absolute levels of and changes in R&D expenditures, another key indicator of the health of industrial science and technology is R&D intensity. R&D is similar to sales, marketing, and general management expenses in that it is a discretionary—i.e., non-direct-revenue-producing—item that can be trimmed when profits are falling. There seems to be considerable evidence, however, that R&D enjoys a high degree of immunity from belt-tightening endeavors—even when the economy is faltering—because of its crucial role in laying the foundation for future growth and prosperity.

There are a number of ways to measure R&D intensity, but the one used most frequently is the ratio of R&D funds to net sales. This statistic provides a way to gauge the relative importance of R&D across industries and firms in the same industry.

The ratio of R&D dollars to net sales tends to be fairly stable over time, although year-to-year changes of 0.1 to 0.2 percentage points are not uncommon. Also, there are

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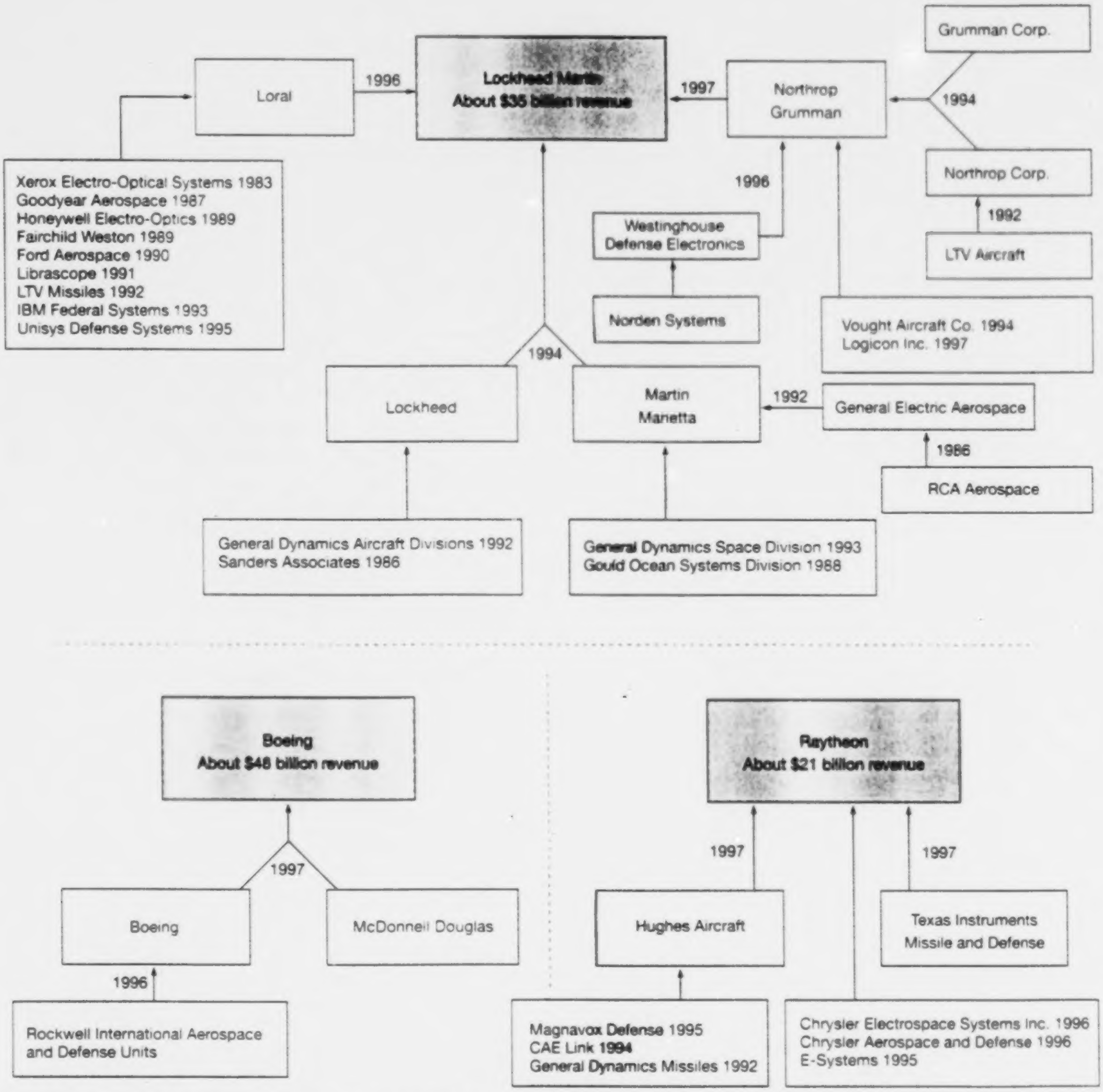
[15] The rapid growth of R&D dollars in the drug industry reflects the high cost of research directed at discovering cures and treatments for diseases like AIDS, other viruses, and drug-resistant bacteria. In addition, managed competition is changing the way drug companies do business in the health care services marketplace; new constraints on pricing could adversely affect R&D (Council on Competitiveness 1996).

[16] Lucent Technologies (ranked sixth in 1996) was split off from ATT in 1996. As a result, Lucent got ATT's top-10 berth on the list, and ATT (ranked 4th in 1986) ranked 36th in 1996. Another company, TRW, restated its R&D expenses reported to the Securities and Exchange Commission in 1996 to include *all* "sponsor-supported" R&D, which means that federal R&D funds are now included in the company's total. As a result, the company earned the seventh highest spot on the 1996 top-100 list.

Figure 4-10.
Consolidation of the U.S. aerospace industry into the "big three"


Grumman Corp.
Loral
1996
Lockheed Martin
About $35 billion revenue
1997
Northrop Grumman
1994
Xerox Electro-Optical Systems 1983
Goodyear Aerospace 1987
Honeywell Electro-Optics 1989
Fairchild Weston 1989
Ford Aerospace 1990
Librascope 1991
LTV Missiles 1992
IBM Federal Systems 1993
Unisys Defense Systems 1995
1996
Northrop Corp.
1992
Westinghouse Defense Electronics
LTV Aircraft
Norden Systems
Vought Aircraft Co. 1994
Logicon Inc. 1997
1994
Lockheed
Martin Marietta
1992
General Electric Aerospace
1986
RCA Aerospace
General Dynamics Aircraft Divisions 1992
Sanders Associates 1986
General Dynamics Space Division 1993
Gould Ocean Systems Division 1988
Boeing
About $48 billion revenue
Raytheon
About $21 billion revenue
1997
1997
1997
Boeing
McDonnell Douglas
Hughes Aircraft
Texas Instruments Missile and Defense
1996
Rockwell International Aerospace and Defense Units
Magnavox Defense 1995
CAE Link 1994
General Dynamics Missiles 1992
Chrysler Electrospace Systems Inc. 1996
Chrysler Aerospace and Defense 1996
E-Systems 1995

NOTE: In March 1998, the U.S. Department of Justice sued to block Lockheed Martin's purchase of Northrop Grumman.

SOURCE: J. Mintz, "How a Dinner Led to a Feeding Frenzy," *Washington Post,* July 4, 1997; and company sources.

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substantial differences between industries. (See appendix table 4-25 and text table 4-4.)

In 1994 and 1995, the most recent years for which data are available, nonfederal R&D spending as a percentage of net sales for all R&D-performing companies classified in manufacturing industries was 2.9 percent. This ratio was four-tenths of a percent less than that recorded for the peak year 1992 and was the first dip below 3.0 percent in 10 years. (See figure 4-11 and appendix table 4-25.) Despite the decline, it is still safe to assume that little change has occurred in the level of importance accorded R&D relative to other discretionary expenditures. That is, roughly the same proportion of compa-

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Text table 4-4.
Industry segments with the highest and lowest company (and other nonfederal) R&D funds/net sales ratios: 1995
(Percentages)

Industry segment	R&D funds/net sales ratio
Highest ratios	
Drugs and medicines	10.4
Office, computing, and accounting machines	8.1
Communication equipment	8.0
Electronic components	8.0
Optical, surgical, photographic, and other instruments	8.0
Scientific and mechanical measuring instruments	6.6
Aircraft and missiles	4.2
Lowest ratios	
Textiles and apparel	0.9
Lumber, wood products, and furniture	0.7
Petroleum refining and extraction	0.7
Food and tobacco products	0.5
Primary metals	0.5

See appendix table 4-25.

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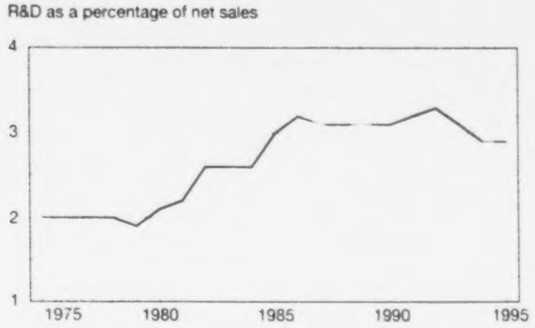
nies' income was devoted to R&D throughout the late 1980s and early 1990s.[17] Minor fluctuations indicate that R&D [illegible] able to hold its own during recessionary periods such as that experienced in the early 1990s and in periods of recovery when profits are outpacing R&D investment.

Disparity in R&D Intensity Across Sectors. As previously mentioned, R&D intensity differs significantly across industries. (See text table 4-4.) Individual industry ratios range from a high of 10.4 percent in the pharmaceutical industry to a low of 0.5 percent in the food and primary metals categories.[18] The pharmaceutical industry has led all other industries since 1993, a reflection of the risky and complex nature of drug research; in 1995, it had the only double-digit ratio. Among the least R&D-intensive industries, only the petroleum industry ranked among the six largest R&D-performing industries.

Federal R&D Funds

In 1997, industrial firms spent an estimated $20.8 billion in federal funds on R&D activities. As mentioned earlier in this chapter, federal R&D support to industry has been declining almost continuously since 1987.

Figure 4-11.
Total nonfederal R&D funding as a percentage of net sales for all manufacturing industries



See appendix table 4-25. *Science & Engineering Indicators – 1998*

The aircraft and missiles industry is the leading recipient of federal R&D funds. Interestingly, this industry formerly accounted for more than two-thirds of all federal monies spent by companies; however, the most recent company-reported data (1995) show it accounting for less than one-half of federal funds. (See appendix table 4-22 and "U.S. Aerospace Firms' Declining Government Sales Offset by Growing Civilian Market.")

A spate of mergers and restructurings has taken place in recent years among defense contractors. Like the "big three" automakers, there are now the "big three" aerospace companies. (See figure 4-10.) For more information on industry's defense-related R&D, see "Independent Research and Development Provides Additional Defense Funding."

Patterns of Federal R&D Support

R&D consumes only a fraction—less than 5 percent—of all public expenditures in the United States. (See "R&D Faring Relatively Well Despite Fiscal Austerity.") Despite their lack of prominence within a trillion-dollar budget, R&D funding trends reflect overall national priorities, including the emphasis on deficit reduction and the shifting balance between defense and domestic programs. For example, a reduction in defense-related programs, facilitated by the end of the Cold War, has been partially offset by increases in support for civilian R&D programs—especially those aimed at improving disease diagnosis and treatment, technological competitiveness, and the environment.

Total federal R&D obligations were an estimated $68.1 billion in fiscal year (FY) 1997, 12 percent below the peak 1989 level (in inflation-adjusted dollars).[19] Defense downsizing, which affected programs at both DOD and DOE, fueled the overall decline. (See appendix table 4-27.)

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[17] It is important to note that there were significant increases in the overall R&D funds net sales ratio between 1981 and 1982 (from 2.2 percent to 2.6 percent) and between 1984 and 1986 (from 2.7 percent to 3.2 percent). Prior to 1982, company R&D funds as a percentage of net sales had been in the 2.0 percent range for 20 years.

[18] R&D outlays in the semiconductor equipment and materials industry are estimated to be about 12 to 15 percent of sales (Council on Competitiveness 1996). The broad industry classification system used in NSF's industrial R&D survey tends to mask pockets of high-tech activity.

[19] An alternative method for measuring federal R&D investment, called the Federal Science and Technology budget, was proposed in 1995 by the National Academy of Sciences. (See "The Federal Science and Technology Budget.")

U.S. Aerospace Firms' Declining Government Sales Offset by Growing Civilian Market

Data from the Aerospace Industries Association (AIA) show sales of aerospace products and services falling from $116 billion in 1991 to $90 billion in 1995, then increasing to $120 billion in 1998 (AIA 1997). The recent increase is attributable to growing sales to commercial customers, although DOD remains the industry's largest single customer. But while DOD used to account for two-thirds of aerospace sales (between 1984 and 1987), it now accounts for slightly more than a third. AIA data show DOD purchases from the aerospace industry declining from $61.8 billion in 1987 to an estimated $42.6 billion in 1998.* In 1998, for the first time, all federal agencies together accounted for less than half of all aerospace sales; from 1984 through 1987, they accounted for approximately three-fourths.

Product group data also show the shift from military to civilian customers:

- Sales of military aircraft fell from $43.7 billion in 1987 to an estimated $30.4 billion in 1998. They now account for 25 percent of all aerospace-related sales, down from nearly half in 1987.
- AIA data show civilian airliner sales surpassing those of military aircraft for the first time in 1997. In 1998, civilian planes and jets are estimated to be 41 percent of all aerospace-related sales, up from only 17 percent in 1987.
- Annual sales of missiles fell 43 percent in the 1990s—from a peak of $14.2 billion in 1990 to $8.0 billion estimated for 1998. As a percentage of all aerospace-related sales, missiles fell from 13 percent in 1990 to 7 percent in 1998.
- Space sales (now just over a quarter of all aerospace-related sales) increased steadily between 1982 and 1992, fell slightly between 1992 and 1994, then increased again to $32.8 billion estimated for 1998.

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*DOD data are a combination of two accounts: (1) procurement and (2) research, development, test, and evaluation.

Independent Research and Development Provides Additional Defense Spending

In addition to the federal R&D obligations discussed in this chapter, DOD's Independent Research and Development (IR&D) Program enables industry to obtain federal funding for R&D conducted in anticipation of government defense and space needs. Because it is initiated by private contractors themselves, IR&D is distinct from R&D performed under contract to government agencies for specific purposes. IR&D allows contractors to recover a portion of their in-house R&D costs through overhead payments on federal contracts on the same basis as general and administrative expenses.

Until 1992, all reimbursable IR&D projects were to have "potential military relevance." Because of the concern that defense cutbacks would reduce civilian R&D—not only in the level of commercial spillovers from weapons research but, more importantly, in reduced DOD procurement from which IR&D is funded—the rules for reimbursement were eased and the eligibility criteria broadened.* Reimbursement is now permissible for a variety of IR&D projects of interest to DOD, including those intended to enhance industrial competitiveness, develop or promote dual-use technologies, or provide technologies for addressing environmental concerns.

In 1996, industrial firms were estimated to have incurred minimally $3.0 billion in IR&D cost, of which $2.9 billion was deemed eligible for reimbursement. The government reimbursed $1.9 billion, or 66 percent of the IR&D total. As a result of the expanded reimbursement eligibility criteria, the amounts reimbursed have held rather steady at about $2 billion per year since 1984. (See appendix table 4-56.) As an equivalent proportion of combined DOD and National Aeronautics and Space Administration (NASA) industrial R&D support, IR&D fell from 11 percent in 1984 to 7 percent in 1996, although this figure is undoubtedly on the low side as a result of accounting and statistical changes. Previously, contractors with auditable costs of $40 million or more were included in the IR&D statistics. The current threshold now includes only those firms with auditable costs of more than $70 million. NASA also reimburses IR&D costs and closely follows DOD procedures. The statistics provided here include reimbursements from NASA. It remains unclear whether changes in the rules governing IR&D have had their intended effect on industrial activity.

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*See NSB (1991) for a brief description of how reimbursement for IR&D was until recently determined. The National Defense Authorization Act for Fiscal Years 1992 and 1993 (P.L. 102-190) provided for the gradual removal of limitations on the amount DOD will reimburse contractors for IR&D expenditures and partially eliminates the need for advance agreements and technical review of IR&D programs.

The Federal Science and Technology Budget

In a 1995 report (NAS 1995) members of a National Academy of Sciences committee proposed an alternative method of measuring the Federal Government's S&T investment. According to committee members and other policymakers, this new approach—titled the Federal Science and Technology (FS&T) budget—provides a better way to track and evaluate trends in public investment in R&D.

The FS&T budget is actually a subset of what is usually referred to as the federal budget for research and development. Advocates of the new approach contend that the traditional method of counting federal dollars spent on R&D overstates the actual amount of federal R&D investment, because certain items are included that should not be. Although no one discounts the importance of production engineering, testing and evaluation, and upgrade of aircraft and large weapons systems, FS&T budget proponents contend that these activities should not be counted as R&D because they do not involve the discovery of new knowledge or the creation of new technologies. Moreover, they are not "major contributor[s] to economic growth, national security, health, [and] quality of life."

If the FS&T were used instead of the traditional budget to evaluate federal R&D investment, DOD's R&D numbers would look quite different. The $25 billion in FY 1997 DOD obligations slated for "major systems development" would no longer be considered R&D and therefore would be subtracted from DOD's total R&D obligations of $33 billion. Doing so would leave $8.0 billion in the FS&T budget, or $3.9 billion in DOD-sponsored research and $4.1 billion in advanced technology development.* In addition, FS&T budget data would show a 9.1 percent decline in DOD R&D obligations between FYs 1994 and 1997—about twice the percentage decline registered when performing a conventional analysis of DOD's R&D investment. (See text table 4-5.)

For all other federal agencies except DOD, the National Academy of Sciences estimates a 3.5 percent increase in the FS&T budget between FYs 1994 and 1996, compared to a 7.4 percent increase using the traditional method.

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*DOD's S&T base provides a substantial portion of all federal support for research and generic technology development in several key areas, including computer science, electrical engineering, and materials.

Text table 4-5.
The FS&T budget for the Department of Defense:
(Millions of current U.S. dollars)

DOD R&D activity	1994	1995	1996	1997	% change 1994-97
Total, FS&T budget	8.8	8.9	8.7	8.0	–9.1
Research	4.3	4.3	3.9	3.9	–9.3
Advanced technology development	4.5	4.6	4.8	4.1	–8.9
Major systems development	25.8	25.4	25.5	25.0	–3.1
Total, traditional federal R&D budget	34.6	34.4	34.3	33.0	–4.6

FS&T = Federal Science and Technology

SOURCES: National Science Foundation, Science Resources Studies Division (NSF/SRS), *Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1956-1996*, NSF 96-320 (Arlington, VA: 1996); and NSF/SRS, *Federal Funds for Research and Development: Fiscal Years 1995, 1996, and 1997*, Detailed Statistical Tables, NSF 97-327 (Arlington, VA: 1997).

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Reduced DOD Prominence in Federal R&D Portfolio

For the first time since 1981, DOD is expected to account for less than half of total federal R&D obligations. (See figure 4-13.) The DOD share of federal R&D spending has been declining steadily since the mid-1980s.

DOD obligations have fallen in both current and constant dollars every year since 1992. In 1997, they stood at an estimated $33 billion, down nearly 20 percent in real terms from the 1992 level. (See appendix table 4-27.)

Despite the receding prominence of DOD in the R&D portfolio, the agency still overshadows all other federal sources of R&D dollars. The Department of Health and Human Services (HHS) is a distant second, with R&D obligations estimated at $12.2 billion in FY 1997. In contrast to the DOD trend, HHS support has been increasing steadily since 1992, although no real growth is expected between 1996 and 1997. (See figure 4-14.)

Between 1992 and 1997, HHS's R&D obligations rose an estimated average of 3.7 percent per year in real terms, and increased to 18 percent—up from 14 percent—of all federal R&D obligations during the same period. This growth reflects the steady stream of new dollars into almost all of the National Institutes of Health (NIH), which account for 95 percent of HHS R&D obligations.

R&D Faring Relatively Well Despite Fiscal Austerity

The President's FY 1998 budget calls for approximately $1.7 trillion in total government spending. Only 4.3 percent of that amount—about $72.6 billion—is designated for R&D programs (including R&D plant).

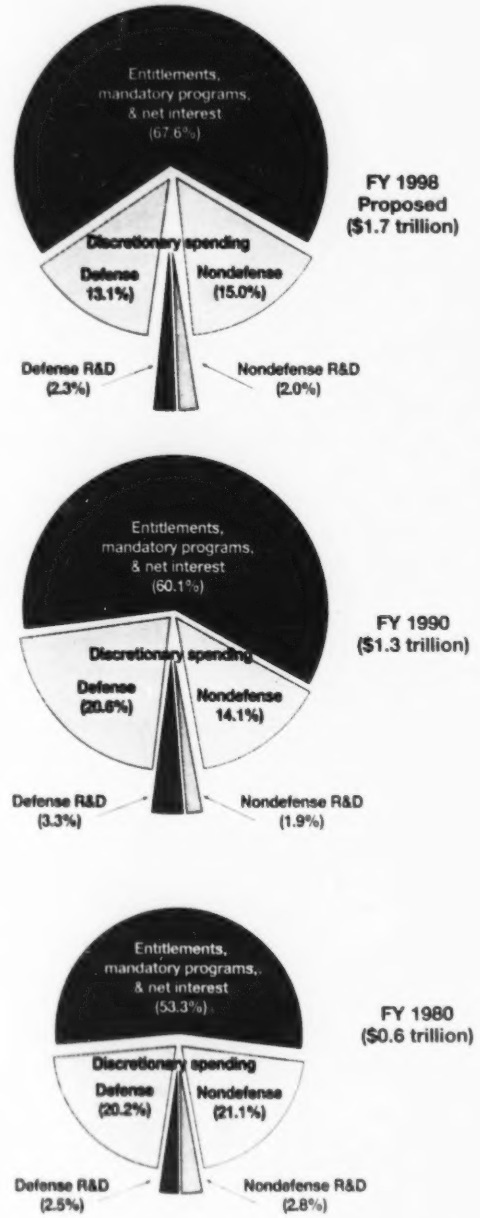
Reducing the deficit has been an overriding goal of both Congress and the Administration. To gain a better understanding of the difficulty involved in accomplishing this objective, it is helpful to split total federal spending into two categories—"mandatory" and "discretionary." Certain program expenditures, including those for Social Security, veterans' benefits, Medicare, Medicaid, and interest on the national debt, are considered mandatory items in the federal budget. That is, the government is already committed by law to financing those programs at certain levels and cannot cut them without serious political repercussions. In contrast, discretionary items, including R&D programs, do not enjoy the same level of protection from budget-cutting proposals; and the Federal Government does not *have* to, or is not already committed by law to, finance such programs at particular levels.

In recent years, the proportion of the federal budget that supports mandatory programs has been expanding while the discretionary share has been shrinking. Mandatory programs are expected to account for more than two-thirds of the total federal budget in 1998—up from less than half prior to 1980. With discretionary programs now comprising less than a third of the total budget, items like R&D and other discretionary programs are becoming increasingly likely candidates for reduction or curtailment to meet deficit-reduction targets.

Despite its increasing vulnerability, R&D has actually fared relatively well during the fiscal austerity of the 1990s. (See figure 4-12.) For example, an examination of R&D as a percentage of the total federal budget reveals the following:

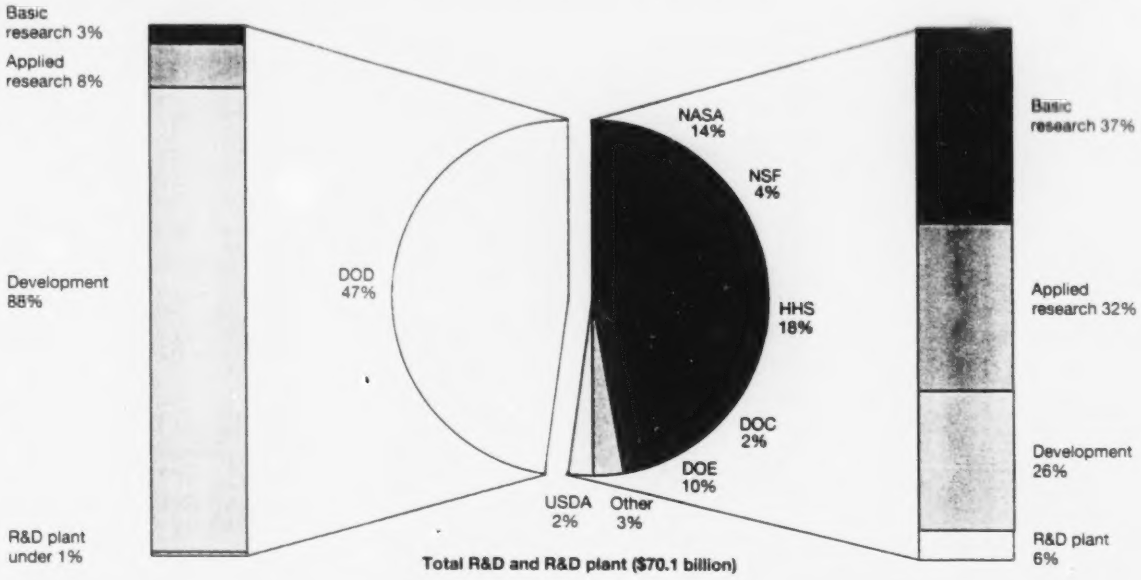
- Although all federally funded R&D is expected to fall from 5.2 percent of the budget in 1990 to 4.3 percent in 1998, nondefense R&D as a percentage of the total budget is expected to remain fairly constant at 2.0 percent during the same period.
- As a proportion of total discretionary spending, R&D has risen from 11.5 percent in 1980 to 13.0 percent in 1990 to 13.3 percent in 1998.
- Nondefense R&D as a percentage of nondefense discretionary spending has been holding fairly steady since 1980 at just under 13 percent.

Figure 4-12.
R&D share of the federal budget



See appendix table 4-26. *Science & Engineering Indicators – 1998*

Figure 4-13.
Projected federal R&D obligations, by agency and character of work: 1997



NOTE: DOC = Department of Commerce; DOD = Department of Defense; DOE = Department of Energy; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation; USDA = Department of Agriculture.

See appendix table 4-27.

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The Major Federal R&D Agencies

In addition to DOD and HHS, five other agencies have R&D budgets that exceed $1 billion. In descending order, they are: the National Aeronautics & Space Administration (NASA), with $9.2 billion in FY 1997 obligations; DOE, $5.9 billion; NSF, $2.3 billion; the Department of Agriculture (USDA), $1.4 billion; and the Department of Commerce (DOC), $1.1 billion. These five agencies—plus DOD and HHS—account for 95 percent of U.S. Government R&D support. (See appendix table 4-27 and figure 4-13.)

NASA and NSF have seen slow expansion of their R&D budgets in the mid-1990s, with average annual constant-dollar increases estimated at 1.3 percent and 1.6 percent, respectively, between 1992 and 1997. (The NASA five-year change, however, includes a 7 percent real reduction estimated for 1996-97.)

In contrast, both DOE and USDA experienced cutbacks. DOE R&D obligations fell about 3.3 percent per year in real terms between 1992 and 1997, and USDA's dropped about 1.8 percent during the same period.

DOC joined the ranks of major R&D funding agencies a few years ago because of its Advanced Technology Program (ATP). DOC's R&D obligations topped $600 million in FY 1992, $800 million in FY 1994, and $1 billion in FY 1995, where they have remained. All of the 1990s gains are largely attributable to ATP. Although ATP continues to represent a major piece of DOC's R&D activities, its future remains uncertain.[20] (See discussion of ATP under "Federal Partnerships With Industry.") DOC's annual level of R&D obligations is expected to have dropped 9 percent in real terms between 1996 and 1997.

Mid-Size R&D Funding Agencies

Three other agencies—the Department of Transportation (DOT), the Environmental Protection Agency (EPA), and the Department of the Interior (DOI)—each have annual R&D obligations of $500 million to $1 billion. Of these mid-size R&D funding agencies, DOT is expected to have shown the largest increase in R&D obligations between FYs 1992 and 1997 (7 percent per year in real terms), while a modest gain and a decrease are expected for EPA and DOI, respectively. The increase in DOT's R&D obligations reflects that agency's current emphasis on R&D related to advancements in the areas of fuel efficiency and emissions, including the Partnership for a New Generation of Vehicles, or Clean Car Agreement. (See "Technology Transfer Activities.")

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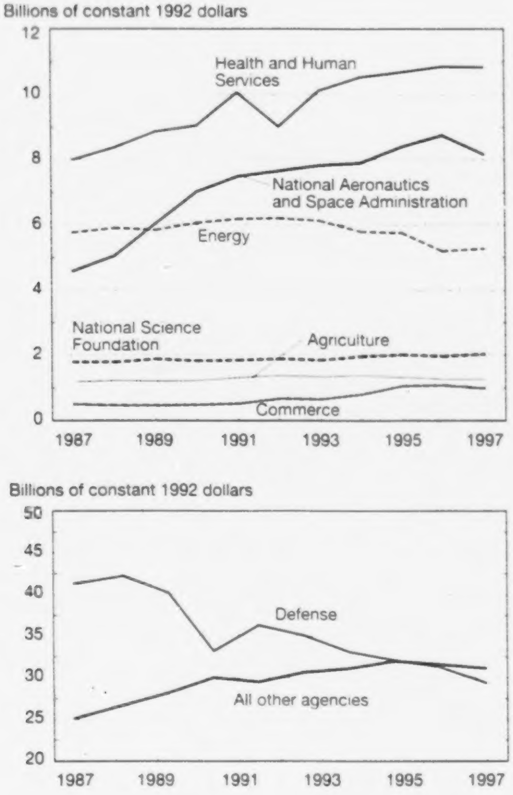
[20] Federal R&D financing has traditionally received strong bipartisan support, but a few fissures in that unanimity—differences in emphasis and priorities—surfaced in the mid-1990s. For example, the major political parties are not in agreement on the role of government in supporting programs like ATP that provide grants to profit-making companies for technology development. Budget debate over ATP has become an annual occurrence.

Figure 4-14.
National R&D obligations, by selected agency



See appendix table 4-27. *Science & Engineering Indicators – 1998*

Federal R&D Support by Character of Work

Federal obligations for basic research, applied research, and development were an estimated $14.7 billion, $14.4 billion, and $38.9 billion, respectively, in FY 1997. Overall, only modest real growth has taken place in both basic and applied research support during the mid-1990s. Each category registered average annual constant-dollar gains of 1 percent between 1992 and 1997. In contrast, the trend in federal support of development—by far the largest slice of the R&D pie—looks quite different, with development obligations in FY 1997 estimated to be more than $2 billion below the FY 1992 level. (See appendix table 4-27.)

Basic Research. After 10 consecutive years (1981-91) of annual real increases in support for basic research, the pace of federal spending on this research type slowed in the 1990s. Although total funding of basic research is continuing to grow in this decade, there have been at least two years in which annual obligations failed to keep pace with inflation.

Five agencies obligate more than $1 billion annually for basic research. HHS, with an estimated $6.6 billion in FY 1997 obligations, accounts for approximately 45 percent of the total. This is more than three times the level obligated by NSF, the second largest supporter of basic research, with $2.1 billion in estimated obligations for FY 1997. The other three agencies are DOE ($2.0 billion), NASA ($1.9 billion), and DOD ($1.1 billion). (See "DOD's Basic Research Programs.") Together, these five agencies accounted for an estimated 93 percent of all federal basic research obligations in FY 1997.

During the 1992-97 interval, HHS, with $1.5 billion, enjoyed the largest absolute increase in basic research funding, more than four times that of NSF, which had the second highest absolute increase ($348 million).

Of the five leading sources of basic research dollars, only DOD's obligations failed to keep pace with inflation between 1987 and 1997. The other four agencies registered average annual growth rates ranging from 1.1 percent for NSF to 3.4 percent for DOE during the same period. For DOE and NASA, the growth took place in the first part of the 10-year period:

DOD's Basic Research Programs

DOD's basic research effort has three main elements, listed below. The DOD organizations responsible for these three elements and their funding levels and projections are given in appendix table 4-28.

- Defense research sciences programs of the armed services, Defense Advanced Research Projects Agency, and the Office of the Secretary are the largest components of DOD's basic research portfolio, accounting for approximately 70 percent of the agency's total basic research funding. They also represent the largest source of DOD research funding for universities—most of which is conducted by single-investigator researchers—and support research undertaken by industry, government laboratories, nonprofit organizations, state and local governments, and FFRDCs.

- In-house Laboratory Independent Research is a program that finances basic research in support of laboratory missions and provides a research environment conducive to the recruitment and retention of outstanding scientists and engineers.

- The University Research Initiative is a collection of academic multidisciplinary research programs.

In 1995, DOD began funding six strategic, multidisciplinary research objectives. They are identified in DOD's Basic Research Plan as biomimetics (with $10.0 million in FY 1997 funding), nanoscience ($23.9 million), smart structures ($8.7 million), broad band communications ($17.2 million), intelligent systems ($18.5 million), and compact power sources ($9.5 million). Funding levels for each of these initiatives remained fairly constant (in current dollars) between FYs 1995 and 1997.

sizable increases between 1987 and 1992 were counterbalanced by little or no growth between 1992 and 1997.

Applied Research. The annual levels in constant 1992 dollars of total federal applied research obligations in the late 1980s and early to mid-1990s produce a wavy trend. (See appendix table 4-27.) Increases in some years were matched by cutbacks in subsequent years. Overall, the annual changes average out to a real increase of 1.7 percent per year between 1987 and 1997, similar to that for basic research. The applied research numbers illustrate that cutbacks in defense-related R&D activities are being counterbalanced by increased government investment in civilian R&D programs, e.g., health and space.

Federal funds for applied research are somewhat less concentrated than basic research dollars. Four agencies (NSF drops out of the group) obligate more than $1 billion annually for applied research and account for approximately three-fourths of all applied research obligations.

HHS is the leading supporter of applied research, with an estimated $4.2 billion in obligations in FY 1997. A large portion of these monies supports research related to the treatment of various diseases, including cancer and AIDS. DOD is second with $2.7 billion; followed by NASA, $2.4 billion; and DOE, $1.5 billion. Among these four agencies, NASA had the largest percentage increase—40 percent in inflation-adjusted dollars—in applied research obligations between 1992 and 1997. HHS registered the second highest percentage increase, with 29 percent, and the largest absolute increase at $1.3 billion.

Although both DOD and DOE recorded healthy increases in applied research obligations in the late 1980s and early 1990s, a turnaround occurred in the mid-1990s. In FY 1997, DOD obligations are estimated to be 30 percent lower in real terms than in FY 1993; DOE's obligations are expected to be down 20 percent between 1995 and 1997. (See appendix table 4-27.)

Development. There has been no real growth in federal obligations for development since FY 1992. (See appendix table 4-27.) Cutbacks averaged an estimated 3.5 percent per year between FYs 1992 and 1997.

DOD is the source of approximately three-fourths of all federal monies spent on development. In FY 1997, DOD obligations for development were an estimated $29.1 billion. These funds have been falling in both current and constant dollars almost continuously, with only two exceptions since FY 1989, the year they peaked at nearly $34 billion.

The other agencies that obligate more than $1 billion annually for development are NASA ($5.0 billion in FY 1997), DOE ($2.3 billion), and HHS ($1.4 billion). NASA development obligations more than tripled between FYs 1987 and 1996; the growth rate averaged 11.4 percent per year in real terms during the nine-year period. However, a 9 percent constant-dollar decrease is estimated for FY 1997. There has been no real growth in DOE obligations since 1990; the average annual rate of decline in constant dollars was 6.5 percent through FY 1997. In real terms, little change has occurred in the annual level of HHS development obligations since 1994, although this agency experienced a major expansion in development funding during the late 1980s and early 1990s.

R&D Agency-Performer Patterns

Most federal R&D funds are actually spent in other sectors of the economy. R&D funding relationships between supporting agencies and performing sectors are well-established and tend to be fairly stable over time. (See appendix tables 4-29 and 4-30 and text table 4-6.) Examples of these funding relationships follow:

- DOD is the source of nearly three-fourths of federal R&D monies spent by industry. Nearly 95 percent of these funds support development work. Two other agencies—NASA and DOE—provide most of the other federal R&D dollars industry receives. (Interestingly, while DOD's proportion of all federal R&D obligations slated for industry fell 3 percentage points in the mid-1990s, NASA's increased by the same amount.)
- HHS is the largest supporter of federally financed R&D performed at universities and colleges, accounting for more than half of all federal R&D funds received by these institutions. In fact, most HHS R&D obligations support work performed in academia; just under one-fifth is spent internally, mostly in NIH laboratories. HHS is also the largest supplier of federal R&D funding for nonprofit organizations. Approximately 5 percent of HHS obligations are slated for industrial firms.
- NSF and DOD are the other leading supporters of R&D conducted in academic facilities. Approximately 80 percent of the NSF research budget supports projects at universities and colleges. The bulk of the remainder is split between other nonprofit organizations (7 percent), university-administered FFRDCs (6 percent), and industry (5 percent).
- DOE and DOD supply the majority of federal R&D obligations for FFRDCs. More than half the DOE R&D budget is spent at FFRDCs.
- Unlike all other federal agencies, USDA, DOC, and DOI spend most of their R&D obligations internally. Most of the R&D supported by these agencies is mission-oriented and is conducted in laboratories run by the Agricultural Research Service, the National Institute for Standards and Technology (NIST), and the U.S. Geological Survey. (See "Other NIST Programs" and appendix table 4-31.)

About half of all federal basic research dollars are spent at universities and colleges. This sector receives most of its basic research support from HHS (53 percent in FY 1997) and NSF (23 percent). Federal obligations for basic research conducted by private firms are concentrated in the research budgets of NASA (48 percent), HHS (21 percent), and DOD (12 percent). Federal in-house work on basic research programs is distributed among several agencies, with the largest portions conducted by HHS (43 percent), NASA (18 percent), and USDA (15 percent). (See appendix table 4-29.)

Text table 4-6.
Estimated federal R&D obligations, by agency and performing sector: 1997

Character of work and performer	Performer, total obligations ($ millions)	Primary funding source		Secondary funding source	
		Agency	Percent	Agency	Percent
Total R&D	68,064	DOD	48	HHS	18
Federal intramural laboratories	16,404	DOD	48	HHS	14
Industrial firms	30,713	DOD	74	NASA	16
Industry-administered FFRDCs	1,340	DOE	70	HHS	17
Universities and colleges	12,362	HHS	57	NSF	15
University administered FFRDCs	3,231	DOE	63	NASA	25
Other nonprofit organizations	2,884	HHS	60	DOD	12
Nonprofit-administered FFRDCs	644	DOD	56	DOE	36
Total, basic research	14,372	HHS	45	NSF	14
Federal intramural laboratories	2,668	HHS	43	NASA	18
Industrial firms	1,279	NASA	48	HHS	21
Industry-administered FFRDCs	368	DOE	65	HHS	34
Universities and colleges	7,405	HHS	53	NSF	23
University administered FFRDCs	1,520	DOE	72	NASA	17
Other nonprofit organizations	1,270	HHS	77	NSF	12
Nonprofit-administered FFRDCs	83	DOE	84	HHS	13
Total, applied research	14,441	HHS	29	DOD	19
Federal intramural laboratories	5,028	DOD	21	HHS	21
Industrial firms	3,521	NASA	42	DOD	34
Industry-administered FFRDCs	637	DOE	83	HHS	12
Universities and colleges	3.418	HHS	64	DOD	9
University administered FFRDCs	611	DOE	72	NASA	15
Other nonprofit organizations	930	HHS	62	AID	12
Nonprofit-administered FFRDCs	109	DOE	63	DOD	13
Total, development	38,890	DOD	75	NASA	13
Federal intramural laboratories	8,708	DOD	75	NASA	14
Industrial firms	25,913	DOD	82	NASA	11
Industry-administered FFRDCs	334	DOE	49	DOD	44
Universities and colleges	1,539	HHS	62	DOD	21
University administered FFRDCs	1,099	DOE	46	NASA	42
Other nonprofit organizations	684	DOD	40	HHS	27
Nonprofit-administered FFRDCs	453	DOD	77	DOE	21

AID = Agency for International Development; DOD = Department of Defense; DOE = Department of Energy; FFRDCs = federally funded research and development centers; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation

See appendix table 4-29.

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Federally Funded R&D Laboratories

Federal R&D obligations for all government laboratories are expected to equal $21.6 billion in FY 1997, 32 percent of total federal R&D obligations. (See text table 4-7.)

In 1995, the U.S. General Accounting Office (GAO) conducted a census of all federal laboratories that perform R&D and are operated by federal agencies or their contractors (U.S. GAO 1996a).[21] A total of 515 laboratories were counted.[22] (See appendix table 4-32.) In addition, 65 of these laboratories had a total of 221 satellite facilities, bringing the actual federal laboratory count to 736. For purposes of this discussion, GAO's identification of 515 laboratories will be used. Seventeen federal departments and independent agencies have laboratories; five (the Department of Housing and Urban Development, Department of Labor, Agency for International Development, Social Security Administration, and U.S. International Trade Commission) have none. At the time of the study, each state had a least one federal laboratory; California had the most with 46. Five laboratories (three run by USDA and two by the Navy) are located in foreign countries.

Of the 515 laboratories, 361 had operating budgets under $10 million in FY 1995, 101 were in the $10 to $100 million range, and 53 had operating budgets exceeding $100 million.

With 185, USDA had the largest number of laboratories in 1995. However, its operations are relatively small in size—with a median operating budget of $2.1 million in FY 1995. According to the GAO survey, DOD, DOE, HHS, and NASA laboratories accounted for 88 percent of all federal R&D laboratory funding in FY 1995. Although most federal laborato-

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[21] Excluded from GAO's survey were facilities whose purpose is to test or analyze samples for chemical, physical, or biological properties, as these activities are not considered R&D.

[22] The various NIH institutes located at the main NIH campus in Bethesda, Maryland, were counted as a single laboratory.

Other NIST Programs

In addition to ATP, the NIST portfolio includes laboratory research and services, the Manufacturing Extension Partnership (MEP), and the Baldrige National Quality Program. These programs were funded at $265 million, $95 million, and $3 million, respectively, in FY 1997.

Laboratory Research and Services. Seven NIST laboratories and the Technology Services organization provide technical leadership for measurement and standards. The laboratories are Electronics and Electrical Engineering, Manufacturing Engineering, Chemical Science and Technology, Physics, Materials Science and Engineering, Building and Fire Research, and Information Technology. To provide NIST with the research environment required for 21st century science, a new Advanced Chemical Sciences Laboratory is under construction, and an Advanced Measurement Laboratory is planned.

Manufacturing Extension Partnership. MEP is a nationwide system of manufacturing extension centers. These centers provide all small and medium-size manufacturers in the United States access to industrial extension services. They also act as gateways into a network of technical resources, services, and expertise related to modern best business practices and manufacturing methodologies. Congress directed NIST to begin helping smaller manufacturers compete in domestic and international markets through passage of the Omnibus Trade and Competitiveness Act of 1988, which also established ATP. In contrast to the solely mission-related R&D agendas of other S&T-related programs, both MEP and ATP were designed exclusively to boost U.S. competitiveness. Since 1989, MEP has made awards for extension center operations covering all 50 states and Puerto Rico.

Baldrige National Quality Program. The Malcolm Baldrige National Quality Improvement Act of 1987 established an annual National Quality Award to promote awareness of quality excellence, to recognize quality achievements of U.S. companies, and to publicize successful quality strategies. The Secretary of Commerce and NIST were given responsibility to develop and administer the award with cooperation and financial support from the private sector. Awards may be given each year in each of three categories: manufacturing companies or subunits, service companies or subunits, and small businesses. There were 32 award winners between 1988 and 1997.

Text table 4-7.
Estimated federal R&D obligations, by selected agency and government laboratory: FY 1997
(Millions of dollars)

Agency	Total R&D	Total lab	Intramural	FFRDCs
Total, all agencies	68,064	21,618	16,404	5,214
Department of Agriculture	1,369	922	922	*
Agricultural Research Service	697	663	663	*
Forest Service	180	154	154	*
Department of Commerce	1,096	712	712	*
National Institute for Standards & Technology	542	226	226	*
National Oceanic & Atmospheric Administration	541	475	475	*
Department of Defense	32,964	8,710	7,919	791
Department of Energy	5,895	3,708	507	3,201
Department of Health & Human Services	12,185	2,632	2,362	270
National Institutes of Health	11,471	2,126	1,857	269
Department of the Interior	574	508	508	*
Geological Survey	524	483	483	*
National Aeronautics & Space Administration	9,204	3,109	2,301	808

* = less than $500,000; FFRDCs = federally funded research and development centers

NOTE: These figures reflect funding levels as reported by federal agencies in March through October 1996.

See appendix tables 4-27, 4-31, and 4-33.

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ries are operated by federal agencies and employ federal personnel, 62 of the 515 were administered by businesses, universities, or other nonprofit organizations through a contract or cooperative agreement with a federal agency.

Federally Funded Research and Development Centers. Thirty-eight of the 736 federal R&D facilities identified by GAO are FFRDCs.[23] They include research laboratories, R&D laboratories, study and analysis centers, and systems engineering/systems integration centers.

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[23] FFRDCs include government-owned and contractor-operated laboratories, and laboratories owned by nongovernment organizations that do virtually all their work for the government.

R&D obligations for these 38 facilities are expected to total $5.2 billion in FY 1997, about 22 percent below the 1992 level. (See appendix table 4-33.) The decline is a reflection of the overall downward trend in defense-related R&D associated with the end of the Cold War. For example, the United States no longer manufactures nuclear warheads, the former mainstay of some of the laboratories. The 1992-97 reduction also reflects removal of FFRDC designation from three facilities administered by industrial firms (formerly there were nine industry-administered FFRDCs; now there are six). Additionally, university- and nonprofit-administered FFRDCs experienced funding cutbacks of 16 percent and 14 percent, respectively, between 1992 and 1997.

Of the FY 1997 FFRDC total of $5.2 billion, $3.2 billion is obligated for 18 university-administered laboratories, $1.3 billion for the 6 run by industrial firms, and $644 million for the 14 facilities operated by nonprofit organizations.

The most well-known FFRDCs are often referred to as "national laboratories." These 10 facilities are funded by DOE. Three were established during World War II specifically to design and build nuclear weapons; six others were created in the decades immediately following the war to develop commercial applications of nuclear technology.[24]

Three of the 10 national laboratories have R&D expenditures that exceed $0.5 billion. They include Sandia, with FY 1995 obligations of about $650 million; Los Alamos, $540 million; and Lawrence Livermore, $500 million. The latter two are administered by the University of California; Sandia is administered by a subsidiary of Lockheed Martin. All three facilities recorded major cutbacks in their R&D programs in the mid-1990s. (See appendix table 4-35.)

Despite an increase in collaborative endeavors with the outside world (see "Technology Transfer Activities"), most of the work conducted at FFRDCs is still defense-related R&D funded by DOE. This agency provided an estimated $3.2 billion in FY 1997, which was a little more than 60 percent of all federal R&D dollars spent at FFRDCs. (See appendix table 4-33.) Between FYs 1992 and 1997, DOE funding fell about 20 percent. DOE is the sponsoring agency for 17 FFRDCs, 11 of which are administered by universities, 4 by industrial firms, and 2 by nonprofit organizations.

NASA now ranks second in terms of R&D funds spent at FFRDCs (it captured second place from DOD in 1995); its FY 1997 R&D obligations are expected to total $800 million. This amount is down about 23 percent from the FY 1995 level of just over $1 billion, but about the same as the levels reported in 1992 and 1994. Most of these funds are spent at the agency's only FFRDC, the Jet Propulsion Laboratory administered by the California Institute of Technology. This laboratory, which serves as NASA's principal center for solar system exploration, is now the largest single FFRDC in terms of R&D financial resources.

FFRDC R&D obligations by DOD are expected to be about $720 million in FY 1997. Total DOD support to FFRDCs has been falling every year since 1992, and now stands at less than half of the 1992 level. As mentioned, one of the reasons for the decline is the removal of FFRDC designation from three industry-administered centers; however, funding also fell about 70 percent ($465 million) at university-administered FFRDCs and 32 percent ($171 million) at nonprofit organizations between 1992 and 1997. DOD is the sponsor of 11 FFRDCs: 2 administered by universities and 9 by nonprofit organizations.

The other agencies that sponsor FFRDCs are NSF, HHS, the Nuclear Regulatory Commission, DOT, and the Treasury Department. Among this group, only NSF sponsors more than one FFRDC; four of its five centers are administered by universities, the fifth by a nonprofit organization. HHS is the fourth largest agency in terms of FFRDC support, with most of its FY 1995 obligations supporting research performed at the National Cancer Institute's Frederick Cancer Research and Development Center, which is administered by four different companies.

Inter-Sector and Intra-Sector Partnerships and Alliances

Collaboration Among Firms and Across Sectors

Cooperative R&D is now an important tool in the development and leveraging of S&T resources. For at least a decade, a combination of several factors has greatly changed the research environment, prompting the creation of inter- and intra-sector—and international—partnerships and other collaborative alliances and enabling them to flourish. Economic, legal, and cultural reasons are responsible for the growth in cooperative R&D:

- **Economic.** Collaboration allows individual partners to leverage their resources, thus reducing costs and risks and enabling research ventures that might not have been undertaken otherwise. In addition, the rise of international competition has forever changed the playing field on which U.S. companies operate, calling for new approaches to innovation.
- **Legal.** New laws have been enacted to encourage collaboration among companies and across sectors. (See text table 4-8.)
- **Cultural.** The traditional reluctance to work with researchers in other organizations—both public and private—has gradually been receding. Attitudes like "not invented here" and an anti-industry bias are far less prevalent than they used to be. Another example of this cultural change is that DOD is now looking first to the commercial sector as a source of new technology for its military needs.

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[24] The 10 laboratories are Lawrence Berkeley, Los Alamos, and Oak Ridge, which were established during World War II to design and build nuclear weapons; Argonne, Brookhaven, Sandia, Idaho Engineering, Lawrence Livermore, and Pacific Northwest, which were created between 1946 and 1965 to advance civilian uses of nuclear technology; and the National Renewable Energy Laboratory, which was established to conduct R&D on alternative energy sources and was given FFRDC status in 1991(U.S. GAO 1994).

Text table 4-8.
Principal federal legislation related to cooperative technology programs

Stevenson-Wydler Technology Innovation Act (1980). Required federal laboratories to facilitate the transfer of federally owned and originated technology to state and local governments and to the private sector. The Act includes a requirement that each federal laboratory spend a specified percentage of its R&D budget on transfer activities and that an Office of Research and Technology Application be established to facilitate such transfer.

Bayh-Dole University and Small Business Patent Act (1980). Permitted government grantees and contractors to retain title to federally funded inventions and encouraged universities to license inventions to industry. The Act is designed to foster interactions between academia and the business community. This law provided, in part, for title to inventions made by contractors receiving federal R&D funds to be vested in the contractor if they are small businesses, universities, or not-for-profit institutions.

Small Business Innovation Development Act (1982). Established the Small Business Innovation Research (SBIR) Program within the major federal R&D agencies to increase government funding of research with commercialization potential in the small high-technology company sector. Each federal agency with an R&D budget of $100 million or more is required to set aside a certain percentage of that amount to finance the SBIR effort.

National Cooperative Research Act (1984). Encouraged U.S. firms to collaborate on generic, precompetitive research by establishing a rule of reason for evaluating the antitrust implications of research joint ventures. The Act was amended in 1993 by the National Cooperative Research and Production Act, which let companies collaborate on production as well as research activities.

Federal Technology Transfer Act (1986). Amended the Stevenson-Wydler Technology Innovation Act to authorize cooperative research and development agreements (CRADAs) between federal laboratories and other entities, including state agencies.

Omnibus Trade and Competitiveness Act (1988). Established the Competitiveness Policy Council to develop recommendations for national strategies and specific policies to enhance industrial competitiveness. The Act created several new programs, including the Advanced Technology Program and the Manufacturing Technology Centers in the Department of Commerce's National Institute of Standards and Technology to help U.S. companies become more competitive.

National Competitiveness Technology Transfer Act (1989). Part of the Department of Defense authorization bill, this act amended the Stevenson-Wydler Act to allow government-owned, contractor-operated laboratories to enter into cooperative R&D agreements.

Defense Conversion, Reinvestment, and Transition Assistance Act (1992). Initiated the Technology Reinvestment Project to establish cooperative, interagency efforts that address the technology development, deployment, and education and training needs within both the commercial and defense communities.

SOURCE: C. Coburn, ed., *Partnerships: A Compendium of State and Federal Cooperative Technology Programs* (Columbus, OH: Battelle Press, 1995).

Although data on financial resources invested in multi-firm and multi-sector collaborative R&D activities are sparse, evidence reveals a major upswing in the number of S&T partnerships since the early 1980s.[25] (See "State R&D Issues: High Geographic Concentration and New Data on State Government R&D Support.") Several indicators of cooperative R&D activity are discussed in this section, which covers only domestic alliances. See "International Strategic Technology Alliances," later in this chapter, for information on international collaborative R&D activities.

Industrial R&D Consortia

In the early 1980s, increasing international competition and the resulting erosion in U.S. technological leadership led legislators and policymakers to conclude that existing U.S. antitrust laws and penalties were too restrictive and could be impeding the ability of U.S. companies to compete in the global marketplace. U.S. companies were at a disadvantage compared to their foreign counterparts, because of an outdated antitrust environment—designed to preserve domestic competition—that prohibited them from collaborating on most activities, including R&D.

Therefore, in 1984, restrictions on multi-firm cooperative research relationships were lifted with the passage of the National Cooperative Research Act (NCRA). (See text table 4-8.) The law was enacted to encourage U.S. firms to collaborate on generic, precompetitive research. To gain protection from antitrust litigation, NCRA requires firms engaging in research joint ventures to register them with the U.S. Department of Justice.[26] In 1993, Congress again relaxed restrictions—this time on cooperative production activities—by

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[25] For example, the Industrial Research Institute's annual survey of its membership shows more than one-third of the respondents (over half in 1996) anticipating an increase in alliances and joint ventures between 1993 and 1998 (IRI 1997).

[26] According to NCRA, an RJV is "any group of activities, including attempting to make, making, or performing a contract, by two or more persons for the purpose of (a) theoretical analysis, experimentation, or systematic study of phenomena or observable facts, (b) the development or testing of basic engineering techniques, (c) the extension of investigative findings or theory of a scientific or technical nature into practical application for experimental and demonstration purposes… (d) the collection, exchange, and analysis of research information, or (e) any combination of the [above]." RJV members can be from different sectors as well as from different countries.

State R&D Issues: High Geographic Concentration and New Data on State Government R&D Support

R&D is substantially concentrated in a small number of states, a solidly entrenched configuration created by past public and private sector choices influenced by multiple economic and scientific considerations.

One-half of the $177 billion spent on R&D in the United States in 1995 was expended in six states—California, Michigan, New York, Massachusetts, New Jersey, and Texas. Add five more states—Illinois, Pennsylvania, Maryland, Ohio, and Washington—and the proportion jumps to two-thirds of the national total. (These figures do not include $6 billion of the national R&D total that could not be allocated to individual states.) One-fifth of all U.S. R&D funds, or $36 billion, was spent in California alone. In each of the next 11 leading states, R&D spending exceeded $5 billion. (See appendix table 4-55.) In contrast, the smallest 20 states together accounted for about $8 billion, or less than 5 percent of the R&D conducted nationwide in 1995.

Not coincidentally, states that are national leaders in total R&D performance also usually rank among the leading sites in industrial and academic R&D performance. (See appendix table 4-55.) Of the 11 states that lead in total R&D:

- All but Maryland ranked among the top 11 in industrial R&D performance; Florida (12th for total R&D) held the 10th slot.
- All but New Jersey and Washington ranked among the top 11 in academic R&D performance; North Carolina and Georgia (16th and 23rd for total R&D, respectively) made the short list instead.

There is somewhat more variation in the distribution of federal R&D performance. Although California ranks third, the top spots were held by Maryland and the District of Columbia, followed by Virginia. These positions reflect the concentration of federal research facilities, such as NIH, in the Washington, D.C., metropolitan area.

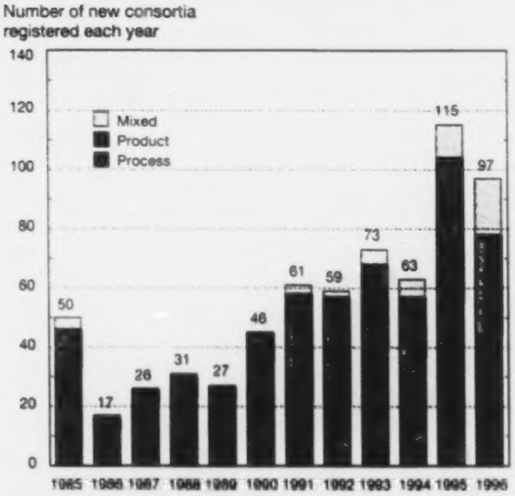
State governments have played an increasingly important role in fostering research collaborations and in helping leverage R&D funds of in-state universities and industry. They also spend an estimated $2.5 billion on R&D activities themselves (Battelle forthcoming). According to preliminary data on state government R&D spending in 1995, California, Florida, and Pennsylvania accounted for the largest funding totals. These were the only three states to individually spend more than $200 million on R&D; combined, the three spent almost $700 million. (See appendix table 4-54.) Most of these monies went to support research undertaken on our nation's campuses. Nationwide, about $400 million was spent in state government agency laboratories. As a percentage of total state funding for all services, however, states overall spent a somewhat meager 0.35 percent on R&D. In only three states—Nebraska, Kansas, and Georgia—did the R&D share exceed 1 percent of state government spending totals, according to available preliminary data.

passing the National Cooperative Research and Production Act, which enables participants to work together to apply technologies developed by their RJVs.

NCRA seems to be accomplishing its objectives. By the end of 1996, more than 665 RJVs had been registered; organizations such as Sematech have helped U.S. industries regain leadership in global markets for high-tech products like semiconductors. Although the annual number of RJV filings has increased in most years since the passage of NCRA, the largest increases were in the two most recent years, including an unprecedented 115 in 1995 and an additional 97 in 1996. (See figure 4-15.) This recent increase may reflect activity from ATP participation. (See "Advanced Technology Program.") Although data are not available on the level of resources invested in these projects, results of two investigations (Link 1996b and Vonortas 1997) revealed the following:

- The average number of members in each of the 665 RJVs is approximately 13. The average number of members in an RJV increased to a maximum of approximately 35 in 1988 and then declined in subsequent years. In 1995, the average membership was about seven, the smallest since NCRA's passage.
- The vast majority—86 percent—of RJV members are profit-making firms. Nonprofit groups, including universities and colleges, hold 10 percent of the memberships; and government agencies and organizations, 4 percent. Registered RJVs with federal participation include some of the more well-known consortia, e.g., Sematech (DOD) and the Advanced Battery Consortium (DOE).
- Most of the research conducted by RJVs has been process-oriented, although during 1991 and 1992, the number of new filings for product-oriented RJVs exceeded the number of those claiming process-oriented research. In general, the more recent data (1991-96), show less skewing toward process-oriented research than do data for 1985-90. In pre-1991 years, the RJV research focus was predominantly process-oriented.

Figure 4-15.
Growth in R&D consortia registered under the National Cooperative Research and Production Act



SOURCE: A.N. Link, "Research Joint Ventures: Patterns From *Federal Register* Filings," *Review of Industrial Organization*, Vol. 11, No. 5 (October): 617-28.

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- ◆ Telecommunications is the dominant RJV technical area, accounting for about one-fifth of the total. The next largest areas are environmental[27] and transportation, each accounting for about 10 percent of the total; followed by advanced materials and energy, each at 9 percent; and software, at 7 percent.
- ◆ Few RJVs involve any type of defense-related research or research in fields where intellectual property rights tend to be well-enforced, e.g., biotechnology, medical equipment, and pharmaceuticals.
- ◆ About 30 percent of RJV members are foreign-based. The most well-represented countries (after the United States) are, in order, the United Kingdom (with 4.9 percent of the total number of entities), Japan (4.6 percent), Canada (3.6 percent), Germany (3.2 percent), and France (2.2 percent).

Federal Programs

Much has been written about the Federal Government's changing role in the development and deployment of new technologies. The postwar "spinoff" model, in which certain industries (e.g., aerospace, computer, and biotechnology) built much of their competitive strength off the government's investment in R&D, has given way to a new model—one in which evidence is pointing to greater government benefits derived from the commercial sector's work in technology development than the other way around. For example, technologies in the software, computer, semiconductor, telecommunication, advanced materials, and manufacturing areas that are pushing the state of the art in U.S. military hardware and equipment were mostly developed in the private sector.

The public sector's evolving role in S&T—and the upsurge in international competition faced by U.S. firms—has led to another change in which the government is taking on the role of "partner" rather than merely customer in federally supported S&T programs. Since 1980, several new programs have come into being, all with the major goal of having the government partner with the private sector to strengthen the U.S. position in international markets for high-tech goods and services. This new approach to technology development and deployment includes the following guideposts:

- ◆ Economic (i.e., commercial potential) as well as technical considerations should play a role in selecting projects to receive public sector support.
- ◆ Cost-sharing is crucial, because it ensures that private sector partners have a stake in the R&D's outcome and success.
- ◆ The private sector should have a major role in project selection and management, because economic growth and jobs—the main benefits of R&D commercialization—are the role of the private sector (U.S. DOC/OTP 1996).

It should be noted that although these new public-private partnerships account for only a small portion of total federal R&D investment in technology, they seem to have broad, widespread support within the private sector.[28]

Technology Transfer Activities

Technology transfer activities became an important mission component of federal laboratories in the late 1980s. Of course, some agencies, including USDA's agricultural research experiment stations and NASA's civilian aeronautics programs, have always shared their research with the private sector.[29] But after Congress passed several laws, including the Stevenson-Wydler Technology Innovation Act (1980), the Federal Technology Transfer Act (1986), and the National Competitiveness Technology Transfer Act (1989), other agencies were given the go-ahead to open their laboratory doors. (See text table 4-8.) In addition, because of budget cutbacks and a decline in defense-related work, federal laboratories have an even greater incentive to stretch their resources through partnering with industry, academia, and state organizations to work on commercially inspired initiatives.[30]

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[27] Environmental research is probably the best example of an area in which market failure results in underinvestment in research. And, because entire industries are affected and can benefit from collaboration, it is a highly appropriate area for joint research. For example, several U.S. companies and national laboratories are involved in a collaborative effort to discover environmental processing techniques for aerospace materials. Although environmental and safety regulations raise the cost of R&D for many companies—especially those in the chemicals, petroleum, and transportation equipment industries—they also promote research that provides numerous societal benefits (Council on Competitiveness 1996).

[28] Support for these programs has been documented by the National Association of Manufacturers, Industrial Research Institute, and Semiconductor Equipment and Materials International (Council on Competitiveness 1996). In addition, a GAO study of manufacturing extension programs found high levels of private sector satisfaction with these programs (U.S. GAO 1995). Another survey revealed a high level of satisfaction among industry officials who had used federal laboratories: e.g., 89 percent of respondents considered their interactions to be a good use of their companies' resources. Even in cases where the costs exceeded the benefits, many industry officials still expressed high levels of satisfaction (Bozeman, Papadakis, and Coker 1995).

Growing Public-Private Cooperation

Evidence of growing cooperation between federal laboratories and private sector entities can be seen in the number of cooperative research and development agreements (CRADAs) executed in the past few years.[31] These formal agreements were created by Congress under "the belief that federal laboratories hold valuable technological assets and that those assets should be used not only for pursuing an agency's mission but also to improve the competitive position of U.S. firms" (U.S. DOC OTP 1996). Thus, the purpose of CRADAs is to facilitate and expedite the transfer of technology from federal laboratories to the private sector by enabling private sector researchers to gain access to and take advantage of government R&D expertise and resources.

Between 1992 and 1995 (the most recent year for which data are available), 3,512 CRADAs were executed. The annual number of new CRADAs more than doubled between 1992 and 1994, going from just over 500 to more than 1,100. However, the annual number of new agreements fell the next year to just over 1,000. (See text table 4-9.)

Text table 4-9.
Number of new cooperative R&D agreements executed, by agency

Agency	Total	1992	1993	1994	1995
Total	3,512	502	877	1,130	1,003
Agriculture	270	41	103	72	54
Commerce	412	86	147	97	82
Defense	1,001	131	201	298	371
Energy	1,553	160	367	564	462
Environmental Protection	43	20	5	10	8
Health & Human Services	136	53	25	36	22
Interior	61	3	15	39	4
Transportation ...	36	8	14	14	0

SOURCE: Technology Publishing Group, *The 1996 CRADA Handbook: Federal Government Cooperative Research and Development Agreements Executed in 1995* (Washington, DC: 1997).

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During the 1992-95 period, DOE executed the largest number of new CRADAs (1,553), followed by DOD (1,001), DOC (412), and USDA (270). Interestingly, every agency except DOD reported a lower number of new CRADAs executed in 1995 than in the previous year. (See text table 4-9.) Government agencies seem to be backing away from these agreements, in contrast to the early 1990s when there was a strong push for them (Larson 1997). DOE had the largest absolute reduction in new CRADAs, as recent budget cutbacks left decreased support for new agreements and prompted termination and scaling back of existing ones, especially at DOE weapons laboratories (Technical Insights 1996).

About 75 percent—or 749—of the 1,003 1995 CRADAs were executed by individual industrial firms; consortia and nongovernment organizations were responsible for 87; universities, 86; and state and local governments, 10.

The total number of private sector partners in the 1995 agreements was 688; 124 organizations executed two or more CRADAs during 1995.

The U.S. Council on Automotive Research, which represents industry's role in the Clean Car Agreement between the Clinton Administration and the "big three" auto makers (and is responsible for R&D associated with the Partnership for a New Generation of Vehicles),[32] executed 32 new CRADAs in 1995, far more than any other private sector partner. (See figure 4-16.) General Motors was a distant second with 15, followed by Dupont with 8, and the University of Maryland with 6. Four companies—AT&T, Chevron, Martin Marietta (now Lockheed Martin), and SI Diamond Technologies—each executed five agreements; and seven organizations executed four.

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[29] For example, NASA has played a lead role in the development of new technologies in propulsion and aerodynamics that have made crucial contributions to the success of the commercial aircraft industry.

[30] According to one survey, companies' major incentives for working with federal laboratories are leveraging R&D, gaining access to federal expertise and facilities, and developing business opportunities—in that order. Respondents also noted that informal types of interaction were the most frequent and effective. "There is a danger that too much emphasis will be placed on evidence of tangible economic payoffs (CRADAs [cooperative research and development agreements], licenses) as measures of success, with insufficient recognition of the value to companies of access to state-or-the-art knowledge and equipment" (U.S. DOC/OTP 1996).

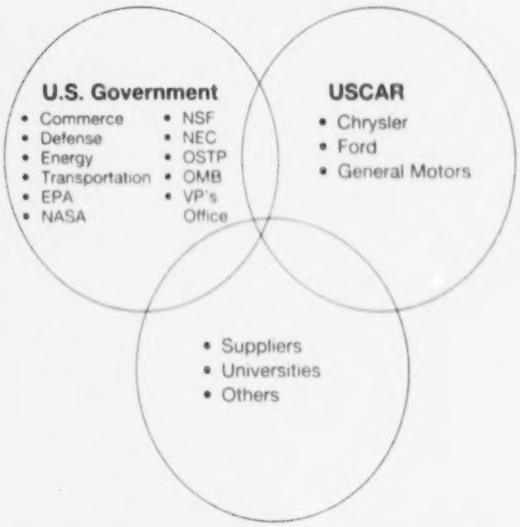
As an example of the growing interaction between federal laboratories and industry, member companies have hosted senior scientists and engineers from Los Alamos, under a special Industrial Research Institute program (Larson 1997a).

On the other hand, pharmaceutical and biotechnology companies have historically been reluctant to work directly with government (NIH) laboratories because of intellectual property and pricing issues (the government reserves the right to control the price of products exclusively licensed by pharmaceutical companies), despite passage of the Technology Transfer Act of 1986, which authorized federal intramural laboratories—including NIH—to offer CRADA partners preference in licensing any intellectual property developed under the CRADA.

[31] Most of the information in this section was obtained from Technology Publishing Group (1997).

[32] The Partnership's purpose is to create a zero-pollution, 80-mile-per-gallon automobile marketable early in the next century.

Figure 4-16.
Partnership for a New Generation of Vehicles relationships



NOTE: EPA = Environmental Protection Agency; NASA = National Aeronautics and Space Administration; NEC = National Economic Council; OMB = Office of Management and Budget; OSTP = Office of Science and Technology Policy; USCAR = U.S. Council on Automotive Research.

SOURCE: Section 10, PNGV Program Plan, July 1994.

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Federal Partnerships With Industry

Two federal technology partnership programs were started in the 1990s: DOC's Advanced Technology Program and DOD's Technology Reinvestment Project (TRP). The purpose behind both programs was to spur the development and deployment of high-risk enabling technologies through an industry-driven, cost-sharing process, whereby industry proposed the research and supplied at least half the funding. Of the two programs, only ATP survives, and its budget was sharply reduced in 1996.

Advanced Technology Program. ATP was designed "to act as a catalyst for the development of high-risk technologies that have broad applications and the potential for large economic impact" (U.S. DOC/OTP 1996), but few federal R&D programs have sparked as much controversy as this one. Neither criticism nor praise for ATP are in short supply. Although the program came into being (as part of the Omnibus Trade and Competitiveness Act of 1988) with substantial bipartisan support, it has come under attack in recent budget debates. The Republican-led Congress has been eager to zero-out a program that provides federal research assistance to corporations.[33] ATP's survival is largely attributable to strong backing from the Clinton Administration and support from the high-tech business community. Although congressional efforts to eliminate the program have yet to succeed, ATP's budget was cut by a third in 1996. Funding remained level in FY 1997 at $218 million, almost 40 percent of NIST's $581 million in appropriated funding.[34]

Between 1990 and 1996, more than $2 billion in public and private funds were invested in a total of 288 ATP projects—184 awards to single applicants and 104 to joint ventures. (See appendix table 4-36 and figure 4-17.) Only about 10 percent of ATP proposals receive funding.

The government's share of ATP is closing in on $1 billion, while private support is slightly above the billion-dollar mark. The 184 single-applicant projects have a total funding level of $600 million, with ATP funds making up slightly more than half that amount and companies providing the remaining portion. The average award size across single applicants and joint ventures is $3.4 million.[35] The 104 joint ventures have a total funding level of $1.4 billion—with just over half of those monies provided by private sector participants.

ATP runs two kinds of competitions—general and focused. Companies or consortia can submit proposals for support in any technology area(s) in the general competitions, while the focused competitions are for specific technologies. The funding split between the two types of competitions is about 40/60 (through 1996). Proposals are selected through a peer review process and are judged on both their technical merit and their potential for commercial success.[36]

ATP has undergone extensive evaluation. NIST-funded case studies and surveys conducted a few years after the program's inception revealed ATP's success in fostering high-risk research that would not have been attempted otherwise. Other benefits were reduced time-to-market, accelerated R&D time tables, job creation, and the formation of strategic R&D alliances. The full economic impact of the program will be examined in future studies, as more projects complete the R&D phase and reach commercial development (U.S. DOC 1995).

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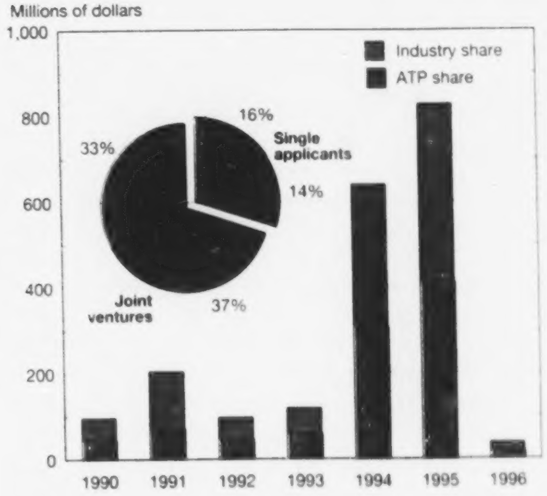
[33] Because ATP is a source of federal funding for technology development that benefits the private sector—and the grants do not have to be repaid or the research results shared—many consider ATP to be a form of "corporate welfare." In the opposite camp are those who believe government has an important role to play in fostering industrial competitiveness by funding research that would not happen without public support. According to one advocate, "ATP plugs a gap that used to make U.S. research vulnerable to foreign competition." The industry official was referring to the perspective that the Federal Government's traditional method of funding research by providing support to academic institutions enables foreign companies to take advantage of the research results at little cost to them (MSNBC 1997).

[34] A $7 million rescission from the $225 million appropriated for ATP made the actual FY 1997 funding level $218 million.

[35] The largest award made was $31.5 million, to a joint venture. Single applications are limited to $2 million (MSNBC 1997).

[36] About 45 ATP projects are classified as "completed," which means the ATP-funded R&D has been done. Several have produced finished products already in the marketplace (MSNBC 1997).

Figure 4-17.
Advanced Technology Program funding



See appendix table 4-36.

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A 1995 GAO study of ATP gave the program a mixed review.[37] While it found the program to be meeting some of its goals—including fostering the formation of joint ventures and facilitating the funding of risky, precompetitive research—the findings also suggested that ATP is funding "research projects that would have been funded by the private sector as well as those that would not" (U.S. GAO 1996b). Not surprisingly, this conclusion provided ammunition for both opponents and proponents of the program (Long 1996).

In response to the congressional criticism, the Secretary of Commerce ordered a report on ATP in March 1997 (U.S. DOC 1997). The following recommendations from this evaluation are being implemented:

- Project evaluation criteria will be modified to put more emphasis on joint ventures and consortia and less on individual applications from large companies.
- The cost-share ratio for large companies applying as single applicants will be increased to a minimum of 60 percent.
- Linkages with the private sector venture capital community will be strengthened.
- State participation through state-sponsored business and technology support programs will be encouraged.

Defense-Related Programs. Defense policy has undergone major changes during the 1990s. Not only has the cessation of Cold War hostilities had a major impact on the size and allocation of the defense budget, but economic considerations and technological advancements are also affecting the U.S. approach to national security. While base closings grab front-page coverage, the less sensational aspects of defense downsizing—namely the paring and reshaping of programs that support scientific research and new technology development—also are being addressed.

During the 1990s, DOD has been pursuing a "dual-use" strategy; i.e., it has been providing financial support to the private sector to develop and deploy technologies likely to have both commercial and military applications. For example, semiflat-panel displays, semiconductors, and smart-weapons technology all have applications in both the commercial and military sectors. The benefits to the government from this approach are assumed to be reduced procurement costs and faster weapons development and improvement cycles.

However, the dual-use approach has attracted a considerable amount of controversy. Opponents contend that it represents an attempt at industrial policy inappropriate for the government in a free-market system. Lack of congressional support led to the demise in 1995 of TRP—the centerpiece of dual-use efforts earlier in the decade.[38]

TRP's successor is called the Dual-Use Applications Program (DUAP). The mission of DUAP is to develop prototypes for and demonstrate new approaches to incorporating commercial research, technology, products, and processes into military systems. The main difference between this and previous dual-use efforts is that the armed services will play a major role by selecting the technology areas they wish to emphasize and support. The FY 1997 DOD appropriation was $135 million to begin funding two DUAP initiatives:

1. The Science and Technology Initiative, with an FY 1997 budget of $85 million. The money will be used to fund projects to develop militarily useful, commercially viable technology. One-quarter of the funding for each project will come from the S&T program, one of the three service branches will supply another quarter, and the remaining half will come from the company performing the work.
2. The Commercial Operations Support Savings Initiative (COSSI), with an FY 1997 budget of $50 million. The money will be used to develop prototypes that leverage commercial R&D to improve the performance of military systems and to decrease operations and support costs. Thirty projects (10 Army, 14 Navy, and 6 Air Force) out of

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[37] GAO surveyed all winning and "near-winning" applicants during ATP's first four years; the response rate was 100 percent.

[38] TRP competitions were held in 1993, 1994, and 1995. The purpose of the program was to fund public-private partnerships to develop technologies for new products and processes meeting both military and commercial needs. It was managed by the Defense Advanced Research Projects Agency, with participation by several other federal agencies. All federal funding, however, was provided by DOD, with industry providing an equal or higher share of financial support for each project. The most recent data show DOD spending to be approximately $700 million on a total of 131 projects awarded TRP support. Focus areas for the 1995 winners were affordable advanced controls technologies, biological sensors and multi-organ diagnostic screening, digital wireless communications and networking systems, microelectromechanical systems applications, operations other than war/law enforcement, and small precision optics manufacturing technology. (See "Independent Research and Development Provides Additional Defense Funding.")

81 proposals were selected for funding in the 1997 competition.[39]

There is also 1997 funding for a third dual-use program. The Commercial Technology Insertion Program will provide approximately $7.5 million in FY 1997 to adapt a commercial signal processing technology to the APG-63 Radar and to qualify microelectromechanical sensors for use in military systems.

Other Federal Cooperative Technology Programs. Other examples of government-industry-academic collaborations include those made under the NSF-funded Science and Technology Centers and Supercomputer Centers and the Grant Opportunities for Academic Liaison with Industry Program. These programs stimulate interactions among industry, academia, and government, mostly through personnel exchanges—which are often identified as the most effective way of transferring knowledge across sectors.

Cross-cutting Administration initiatives have also promoted inter-sectoral collaboration. For example, since 1991, the federal High Performance Computing and Communications (HPCC) Program has been responsible for long-term R&D in advanced computing, communications, and information technologies. The Next Generation Internet, which is part of the HPCC initiative, is bringing together users, network providers, and researchers from all sectors to develop new networks and advanced applications technologies, including new multimedia services for homes, schools, and businesses. (See chapter 8.)

International Comparisons of National R&D Trends

Absolute levels of R&D expenditures are indicators of the breadth and scope of a nation's S&T activities.[40] The relative strength of a particular country's R&D effort is further indicated through comparison with other major industrialized countries. This section provides such comparisons of international R&D spending patterns. It examines absolute and relative expenditure trends, contrasts performer and source structural patterns, reviews the foci of R&D activities, and looks at government priorities and policies. While R&D performance patterns by sector are quite similar across countries, national sources of support differ considerably. Foreign sources of R&D have been increasing in practically all countries.

U.S. leadership in terms of financial investment in R&D compared to other countries' remains largely unchanged from a decade ago, with the U.S. R&D total nearly equal to that of the next six largest performers combined. Virtually all of the major R&D-performing countries experienced a slowing in the growth of R&D funds in the early 1990s, and most continue to feel the funding pinch. The United States and Japan may be exceptions, each reporting significant increases in R&D activity for 1995.

Total Research and Development Trends

Absolute Levels

Worldwide Distribution of R&D. The worldwide distribution of R&D performance is concentrated in several industrialized nations.[41] Of the approximately $410 billion in 1995 R&D expenditures estimated for the 28 Organisation for Economic Co-operation and Development (OECD) countries, 90 percent is expended in just seven (OECD 1997b). These estimates are based on reported R&D investments (for both defense and civilian projects) converted to U.S. dollars with purchasing power parity (PPP) exchange rates. (See appendix table 4-2.) Although PPPs technically are not equivalent to R&D exchange rates, they better reflect differences in countries' laboratory costs than do market exchange rates (MERs). (See "Purchasing Power Parities: Preferred Exchange Rates for Converting International R&D Data.")

The United States accounts for roughly 44 percent of the industrial world's R&D investment total and continues to outdistance, by more than 2 to 1, the research investments made in Japan, the second largest R&D-performing country. Not only did the United States spend more money on R&D activities in 1995 than any other country, but it also spent almost as much by itself as the rest of the major industrialized "Group of Seven" (G-7) countries combined—Japan, Germany, France, the United Kingdom, Italy, and Canada. (See appendix table 4-42.) In only four other countries—the Netherlands, Australia, Sweden, and Spain—do R&D expenditures exceed 1 percent of the OECD R&D total (OECD 1997b).

Worldwide Slowing of R&D Spending. In 1985, spending in non-U.S. G-7 countries was equivalent to 91 percent of U.S. R&D expenditures that year, climbing steadily to peak at 107 percent of the U.S. total in 1992. A worldwide slowing in R&D performance—more pronounced in other countries than in the United States—lowered 1995 R&D spending in these six countries to 101 percent of the U.S. total. (See figure 4-19.)

Total R&D expenditures stagnated or declined in each of the largest R&D-performing countries in the early 1990s. (See figure 4-20.) Indeed, for more than a decade, these G-7 countries have displayed similar aggregate R&D trends: substantial

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[39] COSSI agreements will also allow prime contractors to apply their independent R&D funds as a cost-sharing mechanism. See "Independent Research and Development Provides Additional Defense Funding."

[40] The R&D data presented here for the major industrialized countries are obtained from reports to the Organisation for Economic Co-operation and Development (OECD), which is the most reliable source of such international comparisons. A fairly high degree of consistency characterizes the R&D data reported by OECD, with differences in reporting practices among countries affecting their R&D/GDP ratios by no more than an estimated 0.1 percentage point (ISPF 1993). Although R&D data for non-OECD countries are not as widely available and statistically consistent, many of the less developed and former communist countries have made steady improvements over the past few years to make their R&D statistics more internationally comparable. Several such statistics are referenced within this chapter.

[41] Some developing countries have greatly expanded the level of national resources they devote to civilian research efforts; nonetheless, the overall financial impact of their efforts is small compared with those of large industrialized countries. For example, South Korea—a country that has made considerable strides in expanding its domestic R&D investment—spends about $7 billion annually, a figure equivalent to about 3 percent of the U.S. total. For a review of Korea's recent efforts to strengthen its domestic science and technology base, see OECD (1996b).

Purchasing Power Parities: Preferred Exchange Rates for Converting International R&D Data

Comparisons of international statistics on R&D are hampered by the fact that countries' R&D expenditures are denominated, obviously, in their home currencies. Two approaches are commonly used to normalize the data and facilitate aggregate R&D comparisons. The first method is to divide R&D by GDP, which results in indicators of relative effort according to total economic activity. The second method is to convert all foreign-denominated expenditures to a single currency, which results in indicators of absolute effort. The first method is a straightforward calculation, but permits only gross national comparisons. The second method permits absolute-level comparisons and analyses of countries' sector- and field-specific R&D investments, but entails first choosing an appropriate currency conversion series.

Because, for all practical purposes, there are no widely accepted R&D-specific exchange rates, the choice is between market exchange rates and purchasing power parities. These are the only series consistently compiled and available for a large number of countries over an extended period of time.

At their best, MERs represent the relative value of currencies for goods and services that are traded across borders; that is, MERs measure a currency's relative international buying power. But sizable portions of most countries' economies do not engage in international activity, and major fluctuations in MERs greatly reduce their statistical utility. MERs also are vulnerable to a number of distortions—e.g., currency speculation, political events such as wars or boycotts, and official currency intervention—that have little or nothing to do with changes in the relative prices of internationally traded goods.

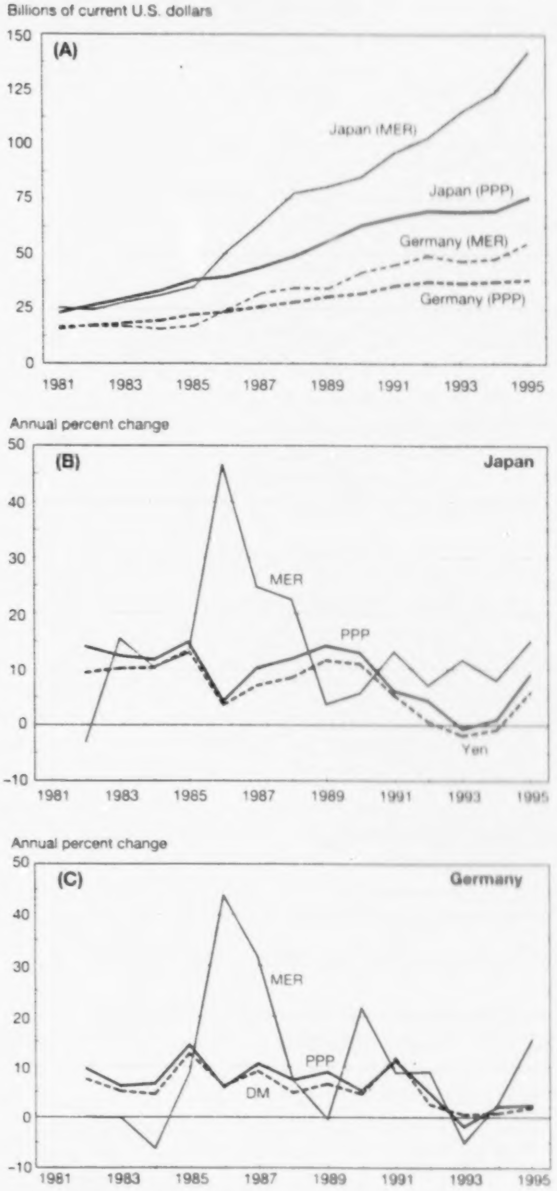
For these reasons, an alternative currency conversion series—PPPs—has been developed (Ward 1985). PPPs take into account the cost differences across countries of buying a similar basket of goods and services in numerous expenditure categories, including nontradables. The PPP basket is therefore representative of total GDP across countries. When applied to current R&D expenditures of other major performers—Japan and Germany—the result is the same: PPPs result in a substantially lower estimate of total research spending than do MERs, as shown in figure 4-18 (A). For example, Japan's R&D in 1995 totaled $76 billion based on PPPs and $142 billion based on MERs. German R&D was $38 billion and $55 billion, respectively. U.S. R&D was $183 billion in 1995.

PPPs are the preferred international standard for calculating cross-country R&D comparisons and are used in all official OECD R&D tabulations. Although there is considerable difference in what is included in GDP-based PPP items and R&D expenditure items, the major components of R&D costs—fixed assets and the wages of scientists, engineers, and support personnel—are more suitable to a domestic converter than to one based on foreign trade flows. Exchange rate movements bear little relationship to changes in the cost of domestically performed R&D. This point is clearly displayed in figure 4-18 (B) and (C). When annual changes in Japan's and Germany's R&D expenditures are converted to U.S. dollars with PPPs, they move in tandem with such funding denominated in their home currencies. Changes in dollar-denominated R&D expenditures converted with MERs exhibit wild fluctuations unrelated to the R&D purchasing power of those investments. MER calculations indicate that, between 1982 and 1995, German and Japanese R&D expenditures each increased in three separate years by 20 percent or more. In reality, nominal R&D growth never exceeded 14 percent in either country during this period.

Worse, MER calculations often result in the wrong direction of implied R&D change. Japan reported reductions in nominal yen R&D in 1993 and 1994, but the use of MERs resulted in positive growth rates of 12 and 8 percent, respectively. PPP-denominated R&D was appropriately negative and flat those two years. Conversely, Japan's MER-denominated R&D expenditures declined in 1982, as did Germany's in 1983, 1984, 1989, and 1993. Yet the home currency-denominated R&D expenditures showed positive changes in each of those years. The use of MERs here is obviously inappropriate: PPP calculations result in generally positive annual R&D expenditure changes that are always considerably closer to the countries' actual funding patterns.

inflation-adjusted R&D growth in the early 1980s, followed by a general tapering off in the late 1980s, then leveling off or declining real R&D expenditures into the 1990s. For most of these countries, economic recessions and general budgetary constraints slowed both industrial and government sources of R&D support; these factors contributed to the major reversal of positive R&D trends in the United States and Japan, where inflation-adjusted R&D spending declined for three consecutive years beginning in 1992. The same general pattern is true for the United Kingdom and Italy, where real growth in the 1980s gave way to declining R&D expenditures, taking into account overall inflation. Unlike in the United States and Ja-

Figure 4-18.
Japanese and German R&D expenditures and annual changes in R&D estimates



NOTE: DM = deutsche mark; MER = market exchange rate; PPP = purchasing power parity.

See appendix tables 4-2 and 4-42.

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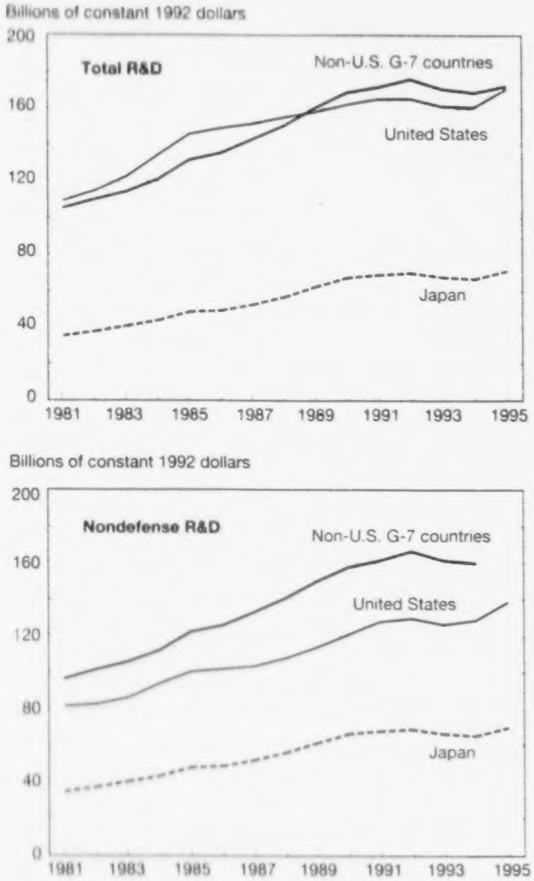
pan, however, R&D spending in these countries has not recovered to previous levels.

Government Cutbacks in Defense-Related R&D. Additionally, changes in the world's geopolitical climate have led to cutbacks in government support for defense-related R&D. Such reductions, in turn, have slowed reported national

Figure 4-19.
U.S. and other G-7 countries' R&D expenditures



NOTE: The non-U.S. G-7 countries are Japan, Germany, France, the United Kingdom, Italy, and Canada.

See appendix tables 4-42 and 4-44.

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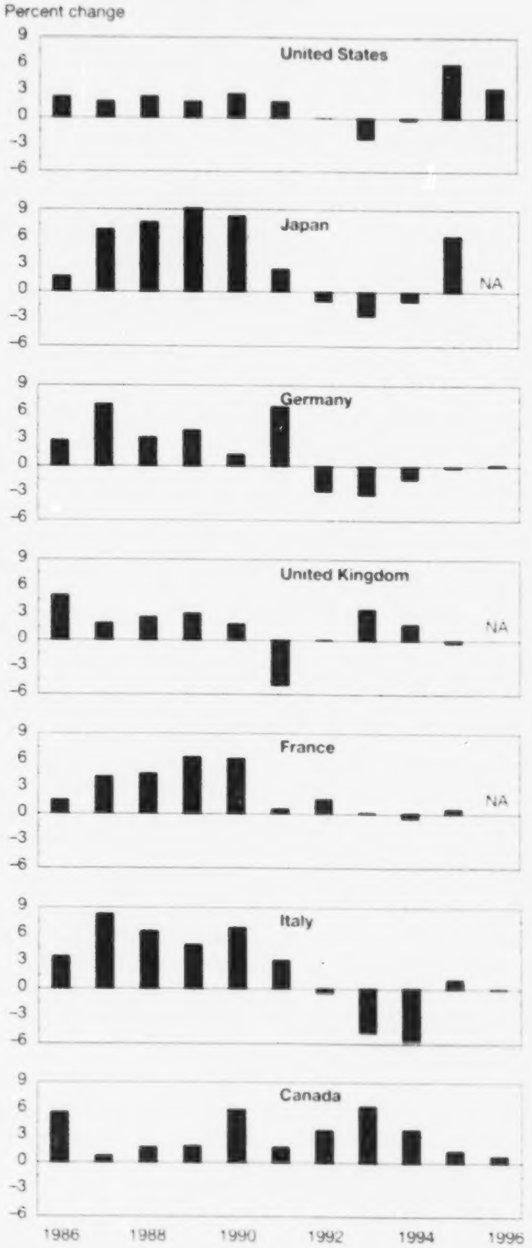
R&D growth patterns in some countries, most notably in the United States, the United Kingdom, and France. For Germany, the integration of the former East German S&T system into the S&T system of West Germany's market economy resulted in an apparent jump in the nation's R&D effort in 1991; it has since been scaled back as a result of the restructuring and closing of inefficient, inappropriate, and redundant research institutions (Government of the Federal Republic of Germany 1993). To date, up to one-third of all former East Germany's R&D institutions have been closed.

Ratio of R&D to GDP

Decreased Ratios in G-7 Countries. The drop in Germany's total R&D effort is indicated by recent trends in its R&D/GDP ratio, one of the most widely used indicators of a country's commitment to growth in scientific knowledge and

Figure 4-20.
Rates of change in total R&D spending for selected countries



NOTES: The inflation-adjusted R&D expenditures reflected in this graph are denominated in foreign currencies deflated by the countries' own GDP price deflators, and therefore are not distorted by exchange rate conversions. NA is not available.

See appendix table 4-42 *Science & Engineering Indicators – 1998*

technology development. (See figure 4-21.) In Germany, the ratio has fallen from 2.9 percent at the end of the 1980s, before reunification, to its current level of 2.3 percent. This pattern is not, however, restricted to Germany. In fact, the latest R&D/GDP ratio in each of the G-7 countries is no higher now than it was at the start of the 1990s. For example, in the United Kingdom and France, R&D/GDP ratios appear to have drifted back from recent peaks to 2.1 and 2.3 percent, respectively. In Italy and Canada, which also have faced economic and budgetary constraints, the R&D/GDP ratios leveled off at about 1.1 percent and 1.6 percent, respectively.

In the United States, R&D's share of GDP similarly declined from 2.7 percent in 1991 to an estimated 2.4 percent in 1994, before climbing back to an estimated 2.6 percent in 1997. As detailed earlier in the chapter, most of the increase in R&D is due to increased support in the industrial sector, primarily by electrical equipment and transportation equipment companies. (See "Industrial Research and Development.") Similarly in Japan, the R&D/GDP ratio fell from 2.9 percent in 1990 to 2.6 percent in 1994, before rising to 2.8 percent in 1995.[42] Both industry and government were responsible for renewed vigor in Japan's R&D spending, with Japan's 1996 Science & Technology Plan suggesting a doubling (in constant yen) of the government's R&D investment by the year 2000 (NSF 1997d).[43]

Severe R&D Downsizing Also in Smaller Countries. The likely reversal of funding trends in the United States and Japan notwithstanding, the recent slowdown in R&D spending has not been confined to OECD's largest industrialized countries. R&D growth during the 1990s in many of the smaller or less technologically advanced European countries has been slower than the growth reported for the 1980s. This is particularly true among Eastern European countries and the former Soviet Union, where market economy transitions have necessitated severe market and industrial adjustments, accompanied by even more severe downsizing of R&D activities (European Commission 1994).

The R&D/GDP ratios shown for Russia and several of the former communist states (see figure 4-22) clearly show the overall decline in those countries' indigenous R&D capabilities since the collapse of the Soviet Union. More recent efforts to stabilize the R&D infrastructure are also apparent in the figure. Poland, Hungary, and the Russian Federation each expend roughly 0.75 percent of GDP on R&D activities; for

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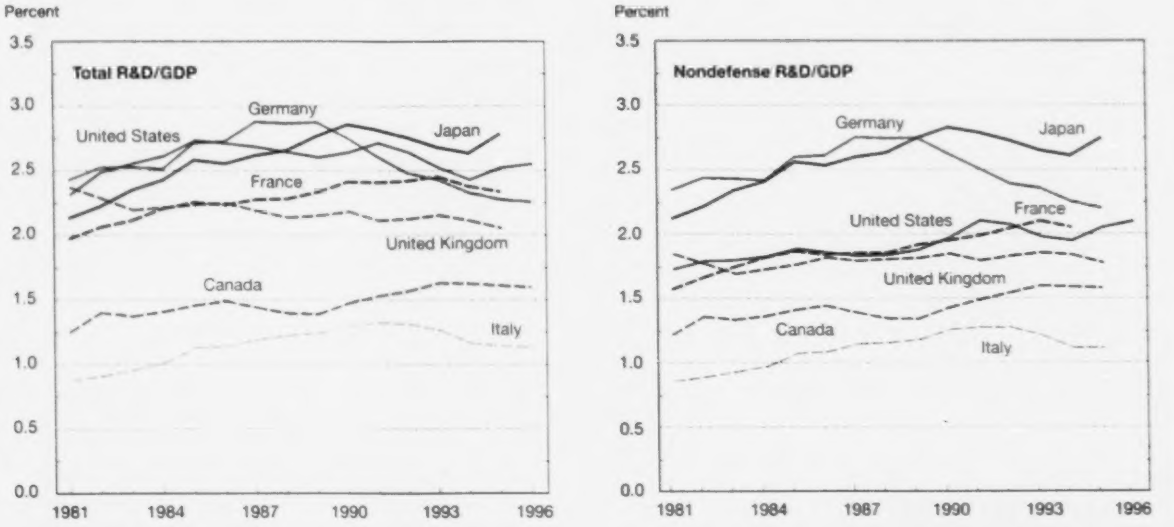
[42] The R&D data reported here for Japan generally reflect the official Japanese statistics adjusted by OECD to make them more comparable with international standards. In Japan, data for R&D personnel are expressed as number of people working mainly on R&D rather than as full-time equivalents. Consequently, R&D labor cost data—and therefore total R&D expenditures—are overestimated by international standards. Based on estimates obtained from recent Japanese studies, OECD reports adjusted Japanese R&D totals that are about 15 percent lower than the official R&D series. For example, the adjusted Japan R&D/GDP ratios reported here are 2.1 percent for 1981, 2.9 percent for 1990, and 2.8 percent for 1995. The unadjusted ratios are 2.3 percent for 1981, 3.0 percent for 1990, and 3.0 percent for 1995.

[43] Although growth in Japanese R&D spending was strongly positive in 1995, more recent problems of overall economic stagnation may foretell another slowing in R&D spending, as was seen in 1992-94, at least by Japanese industrial firms.

Figure 4-21.
R&D as a percentage of GDP for G-7 countries



See appendix tables 4-42 and 4-44.

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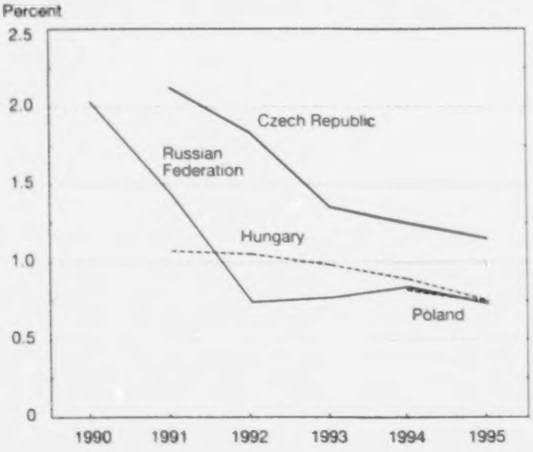
Figure 4-22.
R&D as a percentage of GDP for the Russian Federation and Central European countries



NOTE: Data are not available before 1991 for the Czech Republic and Hungary and before 1994 for Poland.

See appendix table 4-43. *Science & Engineering Indicators – 1998*

the Czech Republic, the R&D/GDP ratio was about 1.2 percent in 1995.

Notably, whether the overall economy has been growing strongly (as in Poland), modestly (as in Hungary and the Czech Republic), or poorly (as in Russia), R&D expenditures have fallen as a share of GDP. Although these governments appear strongly motivated to make institutional changes that foster private sector S&T investments, total R&D expenditures continue to falter. This circumstance is partly explained by looking at the composition of industrial activity in these countries. The more successful examples of private sector growth occur in industrial sectors where small businesses often perform better than larger state-owned enterprises (OECD 1996b). Yet such firms seldom have access to resources on a scale large enough to permit heavy R&D investments. Conversely, the larger state-owned enterprises have been more concerned with needed restructuring and downsizing than with expanding their R&D expenditures.

Effects on R&D of Russia's Economic Restructuring. As recently as 1990, R&D accounted for about 2 percent of the USSR's GDP, with about 40 percent of that amount expended on defense-related activities (Gohkberg, Peck, and Gacs 1997).[44] Indeed, the most advanced aspects of Soviet R&D efforts were undertaken in state-owned enterprises devoted to national security; much of the remaining R&D was performed in other large public industrial institutions in applied research fields that overlapped defense concerns. Most of the basic research was and continues to be in engineering fields.

The introduction of a market economy to Russia brought about drastic economic restructuring that saw a sharp fall in the dominance of state-owned enterprises as well as shrinkage in real GDP, down 38 percent from 1991 to 1995. These trends, in turn, brought about major R&D downsizing, with real R&D expenditures in 1995 less than one-fifth of 1990 levels and with an R&D/GDP ratio of about 0.7 percent. Reflecting the lack of core budgets, entire research institutes have been closed—including many well-equipped laboratories of the former military-industrial complex—and an estimated 43 percent of all researchers from 1990 to 1994 left their government R&D laboratories for the commercial sector or retirement or for other reasons, including emigration.

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[44] R&D data for the Russian Federation are taken from Centre for Science Research and Statistics surveys designed to collect such statistics in accordance with OECD international standards.

Defense now accounts for about 26 percent of Russia's total R&D, a share comparable to that in the United States. According to statistics released by the Russian Ministry of Science and Technological Policy, overall government R&D budget appropriations now represent about 0.74 percent of GDP, three-fifths of which goes for civilian R&D. In 1991, the comparable figures were 1.85 percent of GDP, one-half of which was civil (CSRS 1997). In real terms, the Russian government's 1994 R&D financing was only one-fourth of that in 1991. As a consequence, business enterprise financing has become increasingly important in the Russian Federation, as has R&D funding from foreign research centers, commercial companies, and international organizations.

Nondefense R&D Trends

Absolute Levels

The policy focus of many governments on economic competitiveness and commercialization of research results has shifted attention from nations' total R&D activities to nondefense R&D expenditures as indicators of scientific and technological strength.[45] Indeed, conclusions drawn about a country's relative standing may differ dramatically depending on whether total R&D expenditures are considered or whether defense-related expenditures are excluded from the totals. In absolute dollar terms, the U.S. international nondefense R&D position is still considerably more favorable than that of its foreign counterparts, but not nearly as dominant as when total R&D expenditures are compared. U.S. civil R&D remains twice that of Japan's, but the non-U.S. G-7 countries' combined total is 18 percent more than nondefense R&D expenditures in the United States alone.

Between 1982 and 1990, growth in U.S. nondefense R&D spending was fairly similar to growth in other industrial countries, save Japan, whose nondefense R&D expenditure growth was notably faster. Thus, as an equivalent percentage of the U.S. nondefense R&D total, comparable Japanese spending jumped from 45 percent in 1982 to 55 percent in 1990. (See appendix table 4-44.) During this period, Germany's annual spending equaled 26 to 29 percent of U.S. nondefense R&D spending, while France's annual spending was equivalent to 17 to 18 percent, and the United Kingdom's annual spending fluctuated narrowly between 15 and 16 percent of the U.S. total.

Since 1990, the worldwide slowing in R&D spending and the subsequent apparent recovery in the United States has narrowed the gap between U.S. nondefense R&D spending and that in the other G-7 countries. In 1995, the combined nondefense R&D spending in these six countries equaled $163 billion (in constant PPP dollars), compared with $138 billion (constant dollars) in the United States. Japanese and German spending relative to U.S. spending declined to 50 and 25 percent, respectively.

Ratio of Nondefense R&D to GDP

In normalizing for the size of these economies, the relative position of the United States is slightly less favorable. Japan's nondefense R&D/GDP ratio (2.7 percent) considerably exceeded that of the United States (2.1 percent) in 1995, as it has for years. (See figure 4-21 and appendix table 4-44.) The nondefense R&D ratio of Germany (2.2 percent and declining since a 1989 peak of 2.7 percent) and France (2.1 percent) roughly matched the U.S. ratio; the ratios of the United Kingdom (1.8 percent), Canada (1.6 percent), and Italy (1.1 percent) were somewhat lower. As with total R&D ratios, the nondefense R&D/GDP shares were level or falling in the United States, Germany, and Japan during the early 1990s.

R&D Funding by Source and Performer

By Performer

The large G-7 countries are markedly similar in terms of which sectors undertake the R&D. Industry was the leading R&D performer in each; performance shares in the mid-1990s ranged from a little more than 70 percent in the United States and Japan, to somewhat less than 60 percent in Italy. Industry's share ranged between 60 and 70 percent in Germany, France, the United Kingdom, and Canada. (See figure 4-23 and appendix tables 4-45 and 4-46.) The majority of industry's R&D performance was funded by industry itself in each of these countries, followed by government funding. Government's share of funding for industry R&D performance ranged from as little as 2 percent in Japan to about 18 percent in the United States.

In most of the G-7 countries, the academic sector was the next largest R&D performer (at about 15 to 22 percent of the performance total in each country), followed by government laboratories.[46] Only in France was government's R&D performance (which included spending in several nonprivatized

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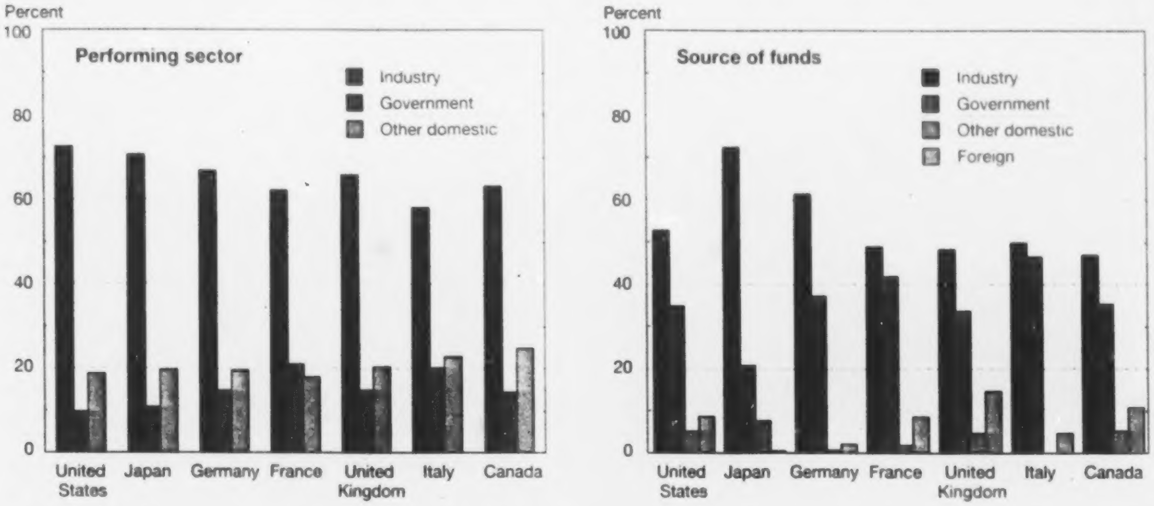
[45] This is not to say that defense-related R&D does not benefit the commercial sector. Unquestionably, technological spillovers have occurred from defense to the civilian sector. But almost as certainly, the benefits are less than if these same resources had been allocated directly to commercial R&D activities. Moreover, considerable anecdotal evidence indicates that technological flow is now more commonly from commercial markets to defense applications, rather than the reverse.

[46] The national totals for Europe, Canada, and Japan include the research component of general university funds (GUF) block grants provided by all levels of government to the academic sector. Therefore, at least conceptually, the totals include both academia's separately budgeted research and research undertaken as part of university departmental R&D activities. In the United States, the Federal Government generally does not provide research support through a GUF equivalent, preferring instead to support specific, separately budgeted R&D projects. On the other hand, a fair amount of state government funding probably does support departmental research at public universities in the United States. Data on departmental research, considered an integral part of instructional programs, generally are not maintained by universities. U.S. totals may thus be underestimated relative to the R&D effort reported for other countries.

Figure 4-23.
R&D expenditures, by country, performer, and source: Mid-1990s



NOTE: Foreign performers are included in the "industry" and "other domestic" performing sectors.

See appendix tables 4-45 and 4-46.

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industries and in some sizable government laboratories) slightly larger than that of academia. Government's R&D performance share was smallest in Japan and the United States, at about 10 percent of each country's total.

For comparison, 66 percent of the 5.1 trillion rubles spent on R&D in the Russian Federation in 1994 was performed within business enterprises; 28 percent was undertaken in the government sector, including the Russian Academy of Sciences; and most of the remaining 6 percent was performed in institutions of higher education. Notably, however, it is reported that universities are having difficulty competing with Academy institutes in basic research and with industry in applied R&D; therefore, the higher education sector is gradually losing its position in the overall R&D effort (Gohkberg, Peck, and Gacs 1997).

By Source

Consistent with performing most of these countries' R&D activities, the industrial sector provides the greatest proportion of financial support for R&D. Shares for this sector, however, differed somewhat from one country to the next. Industry provided more than 70 percent of R&D funds in Japan, 60 percent in Germany, and about 50 percent in the United States, the United Kingdom, Italy, France, and Canada.[47] In each of these seven countries, government was the second largest source of R&D funding and also provided most of the funds used for academic R&D performance.

The R&D funding share represented by funds from abroad ranged from as little as 0.1 percent in Japan to more than 14 percent in the United Kingdom. Indeed, foreign funding—predominantly from industry for R&D performed by industry—is an important and growing funding source in several countries. Although its growth pattern has seldom been smooth, foreign funding now accounts for more than 10 percent of industry's domestic performance totals in France, Canada, and the United Kingdom. (See figure 4-24.) Such funding takes on even greater importance in many of the smaller OECD and less industrially developed countries (OECD 1997a). In the United States, approximately 11 percent of funds spent on industry R&D performance in 1995 are estimated to have come from majority-owned affiliates of foreign firms investing domestically. This amount was up considerably from the 3 percent funding share provided by foreign firms in 1980.[48] (See appendix table 4-46 and "Foreign R&D in the United States.")

Character of the R&D Effort

The categorization of the R&D effort as either basic research, applied research, or development is quite similar among large, R&D-performing countries for which there are recent data. For several of these countries, however, such

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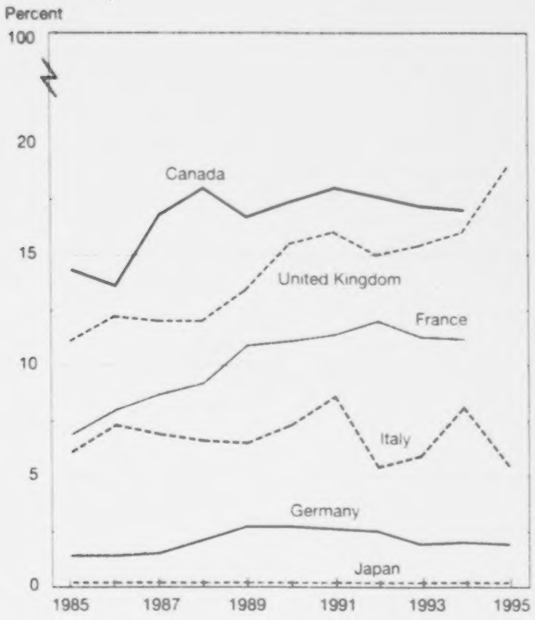
[47] For descriptive statistics on the sectoral composition and size of these OECD countries' industrial R&D activities, see OECD (1997a).

[48] Unlike for other countries, there are no data on foreign sources of U.S. R&D performance. The figures used here to approximate foreign involvement are derived from the estimated percentage of U.S. industrial performance undertaken by majority-owned (i.e., 50 percent or more) nonbank U.S. affiliates of foreign companies. In short, the U.S. foreign R&D totals represent industry funding based on foreign *ownership* regardless of originating source, whereas the foreign totals for the other countries represent *flows* of foreign funds from outside the country to any of its domestic performers.

Figure 4-24.
Share of industry domestic R&D financed from foreign sources



See appendix table 4-49. *Science & Engineering Indicators – 1998*

comprehensive national statistics either are not collected or are considerably out of date. As documented earlier in the chapter, the United States expends about 15 percent of its R&D on activities that performers classify as basic research. (See discussion on basic research in "R&D Support and Performance by Character of Work," earlier in this chapter.) Much of this research is in the life sciences. Basic research accounts for a similar portion of the R&D total in Japan and the Russian Federation—14 percent and 16 percent, respectively. (See figure 4-25.) However, as a share of domestic basic research totals, engineering fields receive relatively more funding in these two countries than in the United States. In France and Germany, the basic research share represented about 21 to 22 percent of the R&D total in the mid-1990s (OECD forthcoming). In each of these countries, development activities accounted for the largest percentage share of total.

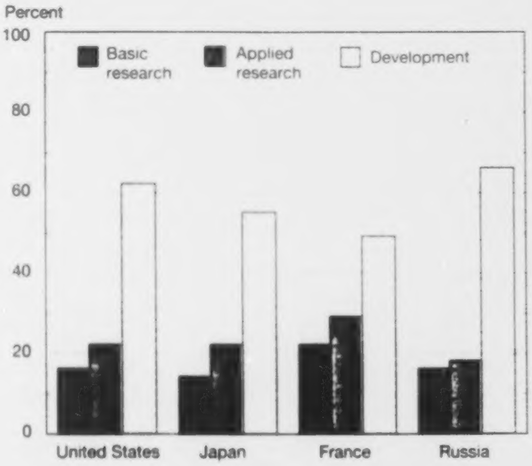
International Comparisons of Government R&D Priorities

The downturn in R&D growth within OECD countries has been disproportionately caused by negative or near-zero growth in government-funded R&D since the late 1980s. These developments are both a reflection of and an addition to the worldwide R&D landscape changes. Such changes are presenting a variety of new challenges and opportunities. The transition of Eastern European communist systems into market economies, the growth of the S&T base in the Pacific Rim, the increase in the international competitiveness of many countries, public and private sector demands for budgetary accountability, evolution of new and emerging technologies, and realignments within industry and at research universities have combined to present governments with historically unparalleled issues of purpose and direction in designing S&T policy. The following sections highlight government R&D funding priorities in several of the larger R&D-performing nations, summarize broad policy trends, and detail indirect support for research that governments offer their domestic industries through the tax code.

Funding Priorities by National Objective

A breakdown of public expenditures by major socioeconomic objectives provides insight into governmental priorities, which differ considerably across countries.[49] In the United States during 1996, 55 percent of the Government's $69 bil-

Figure 4-25.
Distribution of R&D by character of work in selected countries: 1995



NOTES: France's data are for 1994. The character of work for 8 percent of Japan's R&D is unknown. For Germany, 21 percent of its 1993 R&D was basic research and the rest was undistributed.

SOURCES: Organisation for Economic Co-operation and Development, Main Science and Technology Indicators database (Paris: 1997); and Centre for Science Research and Statistics, *Russian Science and Technology at a Glance: 1996* (Moscow: 1997).

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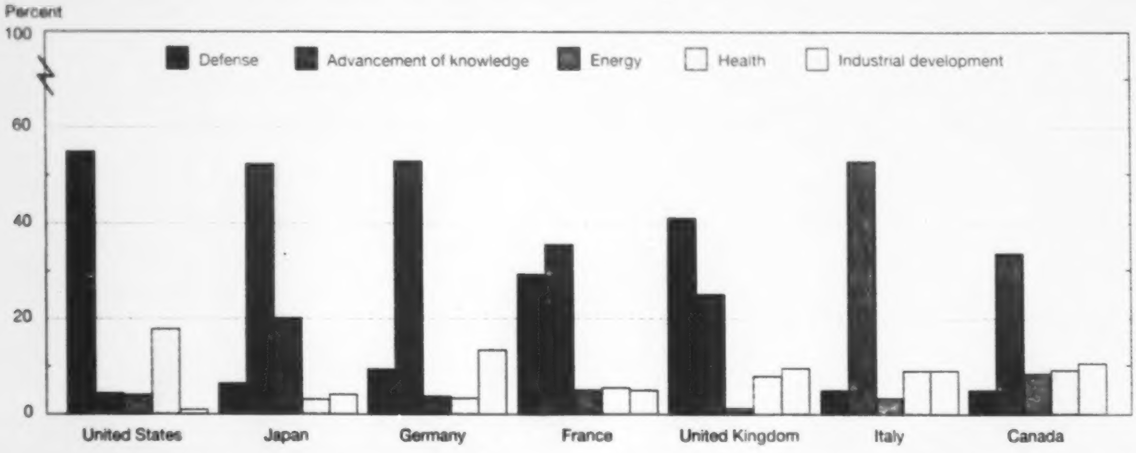
[49] Data on the socioeconomic objectives of R&D funding are rarely obtained by special surveys, but rather are generally extracted in some way from national budgets. Since these budgets already have their own methodology and terminology, these R&D funding data are subject to comparability constraints not placed on other types of international R&D data sets. Notably, although each country adheres to the same criteria for distributing their R&D by objective, as outlined in the OECD's Frascati Manual (1994), the actual classification may differ among countries because of differences in the primary objective of the various funding agents. Note also that these data are of government R&D funds only, which account for widely divergent shares and absolute amounts of each country's R&D total.

Figure 4-26.
Government R&D support, by country and socioeconomic objective: 1995-96



NOTES: Details do not add up to 100 percent because funding for some objectives (e.g., space) is not graphed. R&D is classified according to its primary government objective, although it may support any number of complementary goals. For example, defense R&D with commercial spinoffs is classified as supporting defense, not industrial development. R&D for the advancement of knowledge is not equivalent to basic research.

See appendix table 4-41. *Science & Engineering Indicators – 1998*

lion R&D investment was devoted to national defense; compared with 41 percent in the United Kingdom (of an $8 billion government total); 29 percent in France (of $13 billion); and 10 percent or less each in Germany, Italy, Canada, and Japan. (See figure 4-26 and appendix table 4-41.) These recent figures represent substantial cutbacks in defense R&D in the United States, the United Kingdom, and France, where defense accounted for 63 percent, 44 percent, and 40 percent of government R&D funding, respectively, in 1990. However, defense-related R&D also seems particularly difficult to account for in many countries' national statistics. (See "Accounting for Defense R&D: Discrepancies Between Performer- and Source-Reported Expenditures.")

Different Countries' R&D Emphasis

Advancement of Knowledge. Japanese, German, and Italian government R&D appropriations in 1995-96 were invested relatively heavily (50 percent or more of the $15 billion totals for Japan and Germany, and of the $6 billion total in Italy) in advancement of knowledge—i.e., combined support for advancement of research and general university funds (GUF). Indeed, the GUF component of advancement of knowledge, for which there is no comparable counterpart in the United States, represents the largest part of government R&D expenditure in most of these OECD countries.[50]

Health-Related Research. The emphasis on health-related research is much more pronounced in the United States than in other countries. This emphasis is especially notable in the support of life sciences in academic and similar institutions. In 1996, the U.S. Government devoted 18 percent of its R&D investment to health-related R&D, making such activities second only to defense. (See "Patterns of Federal R&D Support.") Health R&D support approaches 10 percent of total spending in the governmental R&D budgets of the United Kingdom, Italy, and Canada.

Other Areas of R&D Emphasis. In comparison, Japan committed 20 percent of governmental R&D support to energy-related activities, which garnered the second largest share of Japanese R&D, reflecting the country's historical concern with its high dependence on foreign sources of energy. In Canada, 14 percent of the government's $3 billion in R&D funding was directed toward agriculture. Space R&D received

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[50] In the United States, advancement of knowledge is a budgetary category for research unrelated to a specific national objective. Furthermore, whereas GUF is reported separately for Japan, Canada, and European countries, the United States does not have an equivalent GUF category: funds to the university sector are distributed to address the objectives of the federal agencies that provide the R&D funds. The treatment of GUF is one of the major areas of difficulty in making international R&D comparisons. In many countries other than the United States, governments support academic research primarily through large block grants that are used at the discretion of each individual higher education institution to cover administrative, teaching, and research costs. Only the R&D component of GUF is included in national R&D statistics, but problems arise in identifying the amount of the R&D component and the objective of the research.

Government GUF support is in addition to support provided in the form of earmarked, directed, or project-specific grants and contracts (funds for which can be assigned to specific socioeconomic categories). In the United States, the Federal Government (although not necessarily state governments) is much more directly involved in choosing which academic research projects are supported than in Europe and elsewhere. Thus, these socioeconomic data are indicative not only of relative international funding priorities, but also of funding mechanisms and philosophies regarding the best methods for financing research. For the 1995-96 period, the GUF portion of total national governmental R&D support was between 38 and 45 percent in Japan, Italy, and Germany; it was between 16 and 20 percent in the United Kingdom, Canada, and France.

Accounting for Defense R&D: Discrepancies Between Performer- and Source-Reported Expenditures

In many OECD member countries, including the United States, there is a considerable difference in the total government R&D support figures reported by government agencies and those reported by performers of the R&D work. Consistent with international guidance and standards (OECD 1994), however, most countries' national R&D expenditure totals and time series are based primarily on data reported by performers. This convention is preferred because performers are in the best position to indicate how much they spent in the actual conduct of R&D in a given year, and to identify the source of their funds. Although there are many reasons not to expect the funding and performing series to match exactly—e.g., different bases used for reporting government obligations (FY) and performance expenditures (calendar year)—the gap between the two R&D series has widened during the past several years in several of the larger OECD member countries. Additionally, the divergence in the series is most pronounced in countries with relatively large defense R&D expenditures.

For 1995 or thereabouts, statistics from OECD's Main Science and Technology Indicators database show that in only 6 of the 28 member countries does defense account for 9 percent or more of government's total R&D budget (because several OECD member countries have never or not recently reported their R&D defense shares, funding differences in those countries could not be evaluated):

- United States (54 percent),
- United Kingdom (41 percent),
- France (30 percent),
- Sweden (21 percent),
- Spain (10 percent), and
- Germany (9 percent).

These six were precisely the countries for which the sums of performer-reported government R&D funding were substantially less than the total government-reported R&D support estimates. As a percentage of government's reported R&D totals that were not accounted for in each country's performer surveys, the largest gaps were reported for:

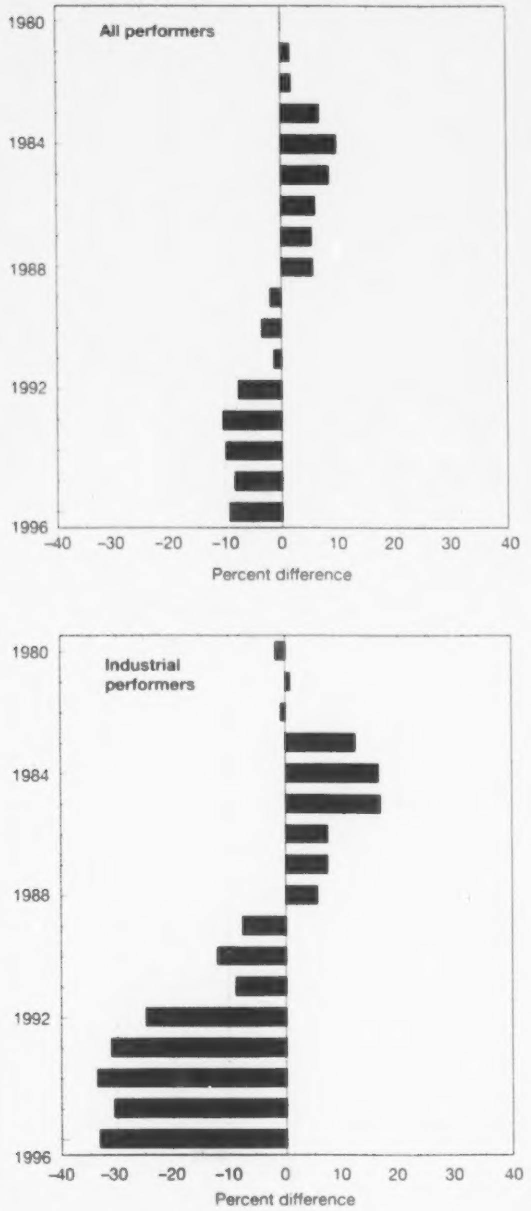
- Sweden (20.4 percent government R&D "leakage"),
- France (18.4 percent),
- United Kingdom (13.0 percent),
- Spain (9.8 percent),
- United States (8.2 percent—taken from national sources, not OECD databases), and
- Germany (7.5 percent).

For the United States, the funding gap has become particularly acute over the past several years. In the mid-1980s, performer-reported federal R&D exceeded federal reports by $3 to $4 billion annually, or 5 to 10 percent of the government total. This pattern reversed itself so that in 1989 the government-reported R&D total exceeded performer reports by $1 billion. The gap has since grown to about $6 billion; in other words, about 10 percent of the government total in the mid-1990s is unaccounted for in performer surveys. (See figure 4-27 and appendix table 4-47.)

Based on preliminary findings, the difference in federal R&D totals appears to be concentrated primarily in DOD development funding of industry (primarily aircraft and missile firms). For 1995, federal agencies reported $30.5 billion in total R&D obligations *provided* to industrial performers, compared with an estimated $21.2 billion in federal funding *reported* by industrial performers. (DOD reports industry R&D funding of $22.7 billion, while industry reports using $13.9 billion of DOD's R&D funds.) Overall, governmentwide estimates equate to a "loss" of 31 percent of federally reported R&D support. (See figure 4-27 and appendix table 4-47.)

A workshop was held recently at NSF (September 1997) to discuss possible causal factors for the divergence. Although circumstances unique to each country contribute to the discrepancy between the two reporting sources, most participants agreed that the problem resides at least partially in reporting R&D for defense and aerospace programs and in tracking government's international R&D flows. In the case of defense and aerospace programs, workshop participants acknowledged possible differences in agency and performer reporting of "the true R&D content" of large extramural contracts where R&D and production activities are mixed. This circumstance is further complicated by the growing use of industry subcontracting and consortia activities in performing large-scale and complex defense projects. For many European countries, these activities are also collaborative and are performed internationally, so that the final R&D performers may be unable to accurately report the origin of the funds. The Science Resources Studies Division at NSF is conducting further research and investigation into these causal phenomena.

Figure 4-27.
Difference in U.S. performer-reported versus agency-reported federal R&D



NOTE: Difference is defined as the percentage of federally reported federal R&D support.

See appendix table 4-47.

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considerable support in the United States and France (each getting 11 percent of the total), whereas industrial development accounted for 9 percent or more of governmental R&D funding in Germany, the United Kingdom, Italy, and Canada. Industrial development programs accounted for 4 percent of the Japanese total, but just 0.6 percent of U.S. R&D. The latter figure is understated relative to other countries as a result of data compilation differences.

Government R&D Trends in the United States

This section provides greater detail on federal R&D funding priorities in the United States. Such priorities shifted overwhelmingly toward defense programs in the 1980s, which included both DOD programs and nuclear weapons research funded by DOE.[51] Defense R&D spending peaked in 1987 at $47 billion (inflation-adjusted 1992 dollars), when it accounted for 69 percent of the federal R&D total. Since then, the data reflect a distinct de-emphasis on defense priorities, as defense-related R&D dropped to 54 percent of the government total in 1995, where it has since remained. (See figure 4-28 and appendix table 4-39.) Proposed federal R&D funding for defense-related activities accounts for 54 percent of the 1998 total.

Of the federal nondefense functions, health—particularly the R&D programs of HHS—experienced the largest inflation-adjusted R&D funding growth since the early 1980s. Indeed, from 1990 to 1998, health R&D has grown by 26 percent (constant 1992 dollars) while funding for all other nondefense functions grew by just 3 percent. Health programs now account for 18 percent of the federal R&D funding total. In particular, AIDS-related research has grown substantially and now accounts for roughly 12 percent of federal health R&D funds, second only to the 16 percent share directed toward cancer research. Funding for space research, second to health among the nondefense functions in the United States, also grew rapidly in the late 1980s and now accounts for 11 percent of the Federal Government R&D total. Most of the R&D funding growth in this area has been in support of Space Station Freedom and its follow-on International Space Station activities.[52]

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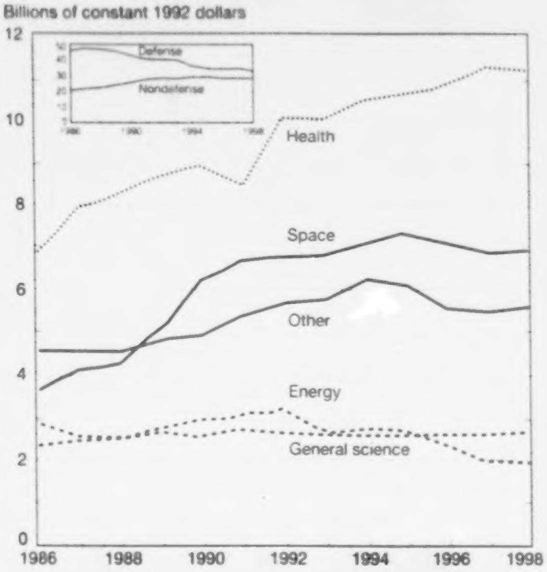
[51] The Office of Management and Budget classifies all activities within the federal budget into 20 functional categories. The budget function classification system provides a means to classify budgetary resources according to the national need being addressed. Fifteen functions contain federal R&D programs. For definitions and details, see NSF (1997c). Data reported here reflect estimates for R&D programs contained in the Administration's 1998 budget proposal submitted to Congress in January 1997 (U.S. OMB 1997). Notably, each specific activity is assigned to only one object code so that programs with multiple objectives will be classified only once under the program's primary functional objective. For example, except for those of the Army Corps of Engineers, all R&D activities sponsored by DOD are classified as defense, even though some activities have secondary objectives such as health, space, or commerce (i.e., defense and commercial dual-use applications). Consequently, these totals are indicative of trends but are not necessarily conclusive. See the recent GAO report for coverage of the Federal Government's total funding by function (U.S. GAO 1997b).

[52] Funding for the Space Station rose from $22 million in 1984, the first year for which this program received a separate budget line item, to $2.1 billion in 1997 (AAAS 1997).

Figure 4-28.
Federal R&D funding, by budget function



NOTE: "Other" includes all nondefense functions not separately graphed, such as agriculture and transportation.

See appendix table 4-39. *Science & Engineering Indicators – 1998*

Among the other major functional recipients of federal R&D funding, general science programs[53] displaced energy activities as the third largest nondefense function in 1996, even though in constant dollars general science research funding is proposed to be no higher in 1998 than it was in 1992. Combined, defense plus these four nondefense functions account for 91 percent of proposed 1998 R&D budget authority.

In terms of *basic* research support, these five functions also account for a 91 percent share of the federal support total, but their relative rankings differ considerably from that for total R&D. (See appendix table 4-40.) Of the proposed $15.3 billion 1998 basic research budget authority, health functions (primarily programs of the National Institutes of Health) account for 46 percent; the general science programs of NSF and DOE for 19 percent; space functions for 10 percent; energy for 9 percent; and defense for 8 percent.

International Comparisons of Government Policy Trends

These aggregate funding priority data only begin to capture the extraordinary changes that have taken place in the international arena over the past several years and the resultant shifts in countries' S&T policy directions. According to a recent OECD (1996) report, a number of common trends among countries are worth highlighting:

- Despite the need to limit public sector expenditures and reduce public sector deficits, support for R&D has remained a priority of public policy throughout OECD member countries. Some countries, such as Japan, have recently announced their intention to increase public sector R&D funding.
- Budgetary restrictions on research funding have led to a growing emphasis on ensuring the efficient use of resources through more extensive program and policy evaluation.
- Many countries are focusing R&D support on specific technologies such as information technologies, energy and environmental technologies, biotechnology, and advanced materials.
- To foster international competitiveness, governments have maintained and expanded measures to strengthen the links between science and industry by establishing initiatives that increase collaboration between higher education and business sectors and between government agencies and industry.
- Many OECD countries have determined that fiscal measures to support industrial R&D represent an important component of public policy aimed at increasing overall R&D and stimulating industrial innovation.

International R&D Tax Treatment

Tax treatment of R&D in OECD countries is broadly similar, with some variations in the use of R&D tax credits (OECD 1996a). The following are main features of the R&D tax instruments:

- Practically all countries (including the United States) allow industry R&D expenditures to be *100 percent deducted* from taxable income in the year they are incurred.
- In most countries, R&D expenditures can by *carried forward* or deducted for some 3 to 10 years. (In the United States, there is a 3-year carry-forward on R&D expenditures and a 15-year carry-forward on R&D capital assets).
- About half the countries (including the United States—see below) provide some type of additional R&D *tax credit* or incentive, with a trend toward using incremental credits and more targeted approaches such as those favoring basic research.
- Several countries have special provisions that favor R&D in small and medium-size enterprises. (In the United States, special credit provisions exist for small startup firms, but more direct federal R&D support is provided through grants to small firms. See "SBIR Program Expands Support for Small Business R&D.")
- There are a growing number of R&D tax incentives being offered at the subnational (provincial and state) levels, including in the United States (see below).

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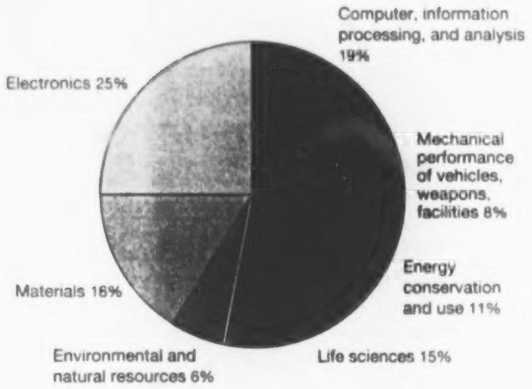
[53] Research activities classified under this "general science" budget category are seen as contributing more broadly to the nation's science and engineering base than do basic research programs that support agency missions.

SBIR Program Expands Support for Small Business R&D

The Small Business Innovation Research (SBIR) Program was created in 1982 to strengthen the role of small firms in federally supported R&D. Since that time, the SBIR Program has directed nearly 37,000 awards worth more than $5.5 billion in R&D support to thousands of qualified small high-tech companies on a competitive basis. Under this program, which is coordinated by the Small Business Administration (SBA) and is in effect until the year 2000, when an agency's external R&D obligations (those exclusive of in-house R&D performance) exceed $100 million, the agency must set aside a fixed percentage of such obligations for SBIR projects. This percentage initially was set at 1.25 percent, but under the Small Business Research and Development Enhancement Act of 1992, it rose incrementally to 2.5 percent in 1997.

To obtain funding, a company applies for a Phase I SBIR grant. The proposed project must meet an agency's research needs and have commercial potential. If approved, grants of up to $100,000 are made to allow the scientific and technical merit and feasibility of an idea to be evaluated. If the concept shows potential, the company can receive a Phase II grant of up to $750,000 to develop the idea further. In Phase III, the innovation must be brought to market with private sector investment and support. No SBIR funds may be used for Phase III activities.

Figure 4-29.
Small Business Innovation Research awards, by technology area: 1983-95



SOURCE: U.S. Small Business Administration, *Small Business Innovation Development Act* (Washington, DC: 1997).

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Eleven federal agencies participated in the SBIR Program in 1995, making awards totaling $865 million—an amount equivalent to 1.3 percent of all government R&D obligations. The total amount obligated for SBIR awards in 1995 was 30 percent more than in 1994, a result of legislatively required increases in R&D amounts agencies must earmark for SBIR. Whereas 71 percent of the *grants* awarded were Phase I grants (3,085 of 4,348 awards in 1995), roughly 70 percent of total SBIR *funds* were disbursed through Phase II grants. Approximately 48 percent of all SBIR obligations were provided by DOD, mirroring this agency's share of the federal R&D extramural funding total. (See appendix table 4-37.)

There have not been many assessments of the overall effectiveness of the SBIR Program, although it is generally agreed that the quality of funded research proposals is high. For example, GAO (1997c) reports that about one-half of surveyed DOD SBIR awards have led to sales of a product, process, or service; about 52 percent of these sales have been made to DOD or to its prime contractors, with remaining sales to private sector customers or others.

SBA classifies SBIR awards into various technology areas. In terms of all SBIR awards made during the 1983-95 period, the technology area receiving the largest (value) share of Phase I awards was advanced materials. Electronics device performance and computer communications systems were the leading technology areas for Phase II awards. More broadly, roughly one-fifth of all awards made from 1983 to 1995 were computer-related and one-fourth involved electronics. (See figure 4-29.) Each received more than 70 percent of its support from DOD and NASA. One-sixth of SBIR awards went to life sciences research, with the bulk of this funding provided by HHS.

U.S. Federal and State R&D Tax Credits

Credits Provided by the Federal Government. As have many other countries, the U.S. Government has tried policy instruments in addition to direct financial R&D support to indirectly stimulate corporate research spending. The most notable of these efforts has been to offer tax credits on incremental research and experimentation (R&E) expenditures.[54] The credit was first put in place in 1981 and has been renewed eight times, most recently through the end of May 1998.[55] Although the computations are complicated, the tax code provides for a 20 percent credit for a company's qualified

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[54] Not all R&D is eligible for such credit, which is limited to expenditures on laboratory or experimental R&D.

[55] In its latest extension, the credit was renewed in August 1997 retroactive to June 1997. The credit had lapsed from mid-1995 to mid-1996 before being restored in 1996 to a modified form. See also Poterba (1997) for a discussion of international elements of corporate R&D tax policies.

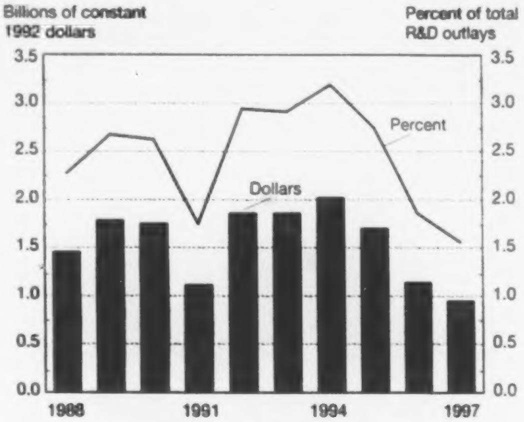
R&D amount that exceeds a certain threshold.[56] Since 1986, companies have been allowed to claim a similar credit for basic research grants to universities and other qualifying nonprofit institutions, although the otherwise deductible R&E expenditures are reduced by the amount of the basic research credit. This basic research provision generally has gone unutilized.[57]

The dollar value of R&E tax credits actually received by firms is unknown. Not all of the tax credits initially claimed by firms are allowed. Indeed, data from the Internal Revenue Service indicate that in any given tax year, this dollar value can be 20 to 30 percent less than the amount for which firms file claims—nearly $1.6 billion in 1992, the most recent year for which data are available (U.S. OTA 1995). This amount has fluctuated since the credit's inception in 1981, but has remained rather steady since 1988. (See appendix table 4-38.)

Additionally, as part of the federal budget process, Treasury annually calculates estimates of foregone tax revenue (tax expenditures) resulting from preferential tax provisions, including the R&E tax credit. As one measure of budgetary effect, Treasury provides outlay-equivalent figures that allow a comparison of the cost of this tax expenditure with the cost of a direct federal R&D outlay. Between 1981 and 1996, more than $27 billion was provided to industry through this indirect means—an amount equivalent to about 3 percent of direct federal R&D support. (See figure 4-30 and appendix table 4-38.)

Effectiveness of Credits Uncertain. Results of various studies undertaken since the mid-1980s have given the tax credit mixed reviews for its overall effectiveness. Assessments undertaken soon after initial enactment of the credit (those using data for the years 1981 to 1983) concluded that the R&E tax credit cost more in lost revenues than it produced in additional R&E expenditures. More recent and somewhat more comprehensive studies (using data for the years 1988 and later) indicate that the amount of induced R&E spending approximates revenue cost in the short term and exceeds it in the long term (U.S. OTA 1995 and U.S. GAO 1996c).[58] Although some firms rely heavily on the credit—e.g., industries with rapidly expanding R&D outlays (as in communications and information technology) and industries for which R&D performance strongly affects market valuation (as in biotechnology)—preliminary evidence indicates that the R&E tax credit rarely factors into individual firms' R&D planning processes. There are no studies that have empirically investigated the credit's net benefit to society.

Figure 4-30.
R&E tax credits: Total and percentage of government R&D outlays



NOTE: Bar charts represent outlay equivalents of research and experimentation (R&E) tax credits.

See appendix table 4-38. *Science & Engineering Indicators – 1998*

Credits Provided by State Governments. The Federal Government is not the only source of fiscal incentives for increasing research. According to a recent survey of the State Science and Technology Institute (1997), 35 states offered some type of incentive for R&D activity in 1996. Many states offered an income tax credit modeled after the federal R&E credit guidelines. Fifteen states applied the federal research tax credit concepts of qualified expenditures or base years to their own incentive programs, although they frequently specified that the credit could only be applied to expenditures for activities taking place within the state. Other types of R&D incentives included sales and use tax credits and property tax credits.

Internationalization of R&D and Technology

Globalization of R&D activities has expanded considerably during the past two decades. This growth is exhibited in each of the R&D-performing sectors. Gains in cross-country academic research collaboration are indicated by the substantial increase in international coauthorships. (See chapter 5, "Trends in International Article Production.") In the public sector, the rapid rise in international cooperation has spawned activities that now account for up to 10 percent of government R&D expenditures in some countries. International collaboration in scientific research involving extremely large "megascience" projects also has grown, reflecting scientific and budgetary realities. Excellent science is not the domain of any single country, and many scientific problems involve major instrumentation and facility costs that appear much more affordable when cost-sharing arrangements are in place. Additionally, some scientific problems, such as global change research, demand an international effort.

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[56] The complex base structure for calculating qualified R&D spending was put in place by the Omnibus Reconciliation Act of 1989. With various exceptions, a company's qualifying threshold is the product of a fixed-base percentage multiplied by the average amount of the company's gross receipts for the four preceding years. The fixed-base percentage is the ratio of R&E expenses to gross receipts for the increasingly distant 1984-88 period. Special provisions cover startup firms.

[57] In 1992, firms applying for the R&E credit spent about $1 billion on research performed by educational and scientific organizations, of which—after various qualification restrictions—the basic research credit contributed less than $200 million toward the R&E tax credit (U.S. OTA 1995).

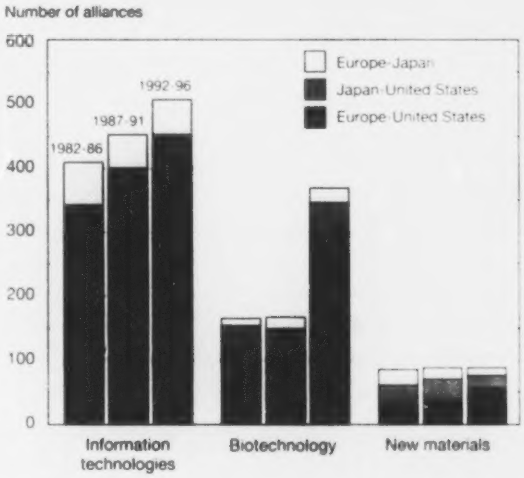
[58] Whatever its ultimate impact on R&D spending, the tax credit has certainly influenced spending less than it could have, were it less subject to erratic legislative treatment. The tax credit has had to be repeatedly (almost annually) renewed, its calculation provisions have changed considerably over the years, and it was even allowed to lapse several times—circumstances that created considerable uncertainty for businesses that otherwise would have planned to take the credit.

In the private sector, international R&D collaboration is also on the rise, as is indicated by the growth of formal cooperative partnerships between firms. Growing international linkages are evidenced as well by the rise of overseas R&D activities performed under contract and through subsidiaries, and by the establishment of independent research facilities. Although the reasons for this growth are complex, multilateral industrial R&D efforts appear to be a response to the same competitive factors affecting all industries: rising R&D costs and risks in product development, shortened product life cycles, increasing multidisciplinary complexity of technologies, and intense foreign competition in domestic and global markets.

International Strategic Technology Alliances

Industrial firms increasingly have sought global research partnerships as a means of strengthening their core competencies and expanding into technology fields considered critical for maintaining market share. Such international strategic technology alliances increased sharply throughout the industrialized world in the early 1980s and accelerated as the decade continued.[59] Although growth of newly established alliances tapered off in the early 1990s, there is evidence of further expansion during the middle part of this decade. Formation of these strategic technology partnerships has been particularly extensive among high-tech firms in such core areas as information technologies, biotechnology, and new materials. (See figure 4-31 and appendix table 4-48.) Technological complementarity and reduction of the innovation period are primary catalysts for entering into core technology alliances; market entry and production-related factors are more relevant in technologically less advanced or more mature markets.

Figure 4-31.
New international strategic technology alliances, by technology and world region



See appendix table 4-48. *Science & Engineering Indicators – 1998*

Nature of Cooperative Activity Changing

As the numbers have increased, the forms of cooperative activity have changed as well. The most prevalent modes of global industrial R&D cooperation in the 1970s were joint ventures and research corporations. In these arrangements, at least two companies share equity investments to form a separate and distinct company; profits and losses are shared according to the equity investment.[60] In the second half of the 1980s and continuing into the 1990s, joint nonequity R&D agreements became the most important form of partnership. Under such agreements, two or more companies organize joint R&D activities to reduce costs and minimize risk, while pursuing similar innovations. Participants share technologies but have no joint equity linkages (Hagedoorn 1990 and 1996).

Growth in Core Technology Alliances

During the first half of the 1970s, strategic alliances were almost nonexistent in core technologies, as well as in other sectors, but expanded rapidly late in the decade. The number of newly made partnerships in the three core technologies—information technologies, biotechnology, and new materials—rose from about 10 alliances created in 1970 to about 140 in 1980 (Hagedoorn 1996). By 1986, this number had risen to 400 alliances, 250 of which were intraregional (that is, made between firms located in the same broad regions of Europe, Japan, or the United States); 150 were interregional (between firms located in separate regions). The majority of both types of alliances was between firms sharing information technologies such as computer software and hardware, telecommunications, industrial automation, and microelectronics.

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[59] Information in this section is drawn from an extensive database compiled in the Netherlands (MERIT-CATI—Maastricht Economic Research Institute on Innovation and Technology's Cooperative Agreements and Technology Indicators database) on more than 10,000 inter-firm cooperative agreements involving thousands of different parent companies. In the CATI database, only agreements that contain arrangements for transferring technology or joint research are collected. The data summarized here extend by three years the information for 1970 to 1993 presented in Hagedoorn (1996). These counts are restricted to strategic technology alliances, such as joint ventures for which R&D or technology sharing is a major objective, research corporations, joint R&D pacts, and minority holdings coupled with research contracts.

CATI is a literature-based database; its key sources are newspapers, journal articles, books, and specialized journals that report on business events. CATI's main drawbacks and limitations are that (1) data are limited to activities publicized by the firm, (2) agreements involving small firms and certain technology fields are likely to be underrepresented, (3) reports in the popular press are likely to be incomplete, and (4) it probably reflects a bias because it draws primarily from English-language materials. CATI information should therefore be viewed as indicative and not comprehensive.

[60] Joint ventures are companies that have shared R&D as a specific company objective, in addition to production, marketing, and sales. Research corporations are joint R&D ventures with distinctive research programs.

For the decade since 1986, growth in core technology alliances has been continuous though irregular. Of the roughly 2,500 information technology alliances formed during this period, the largest number has been among U.S. companies and between European and U.S. firms. Among the 1,100 strategic biotechnology alliances, U.S.-European interregional partnerships have been more prevalent than any other, especially during the mid-1990s. In fact, by 1996 almost 60 percent of all biotechnology collaborations were interregional. The opposite was true of partnerships focusing on information technology, for whom intraregional alliances were created twice as often as interregional partnerships in 1996. (See figure 4-32.)

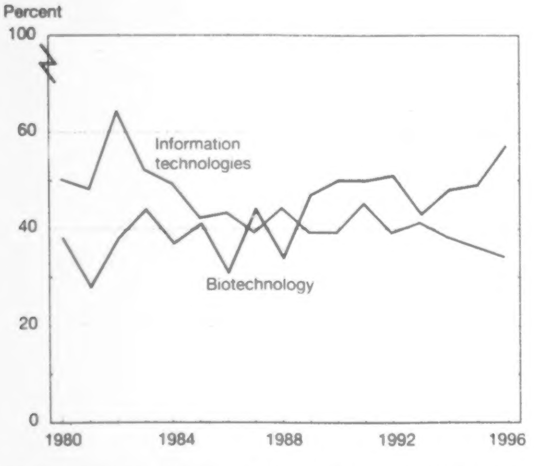
U.S. Industry's International R&D Investment Balance

Stiff international competition in research-intensive, high-technology products, along with market opportunities, have compelled firms throughout the world to expand their overseas research activities. Foreign sources account for a growing share of domestic R&D investment totals in many countries (see figure 4-24), and many firms have R&D sites in countries outside of their home base. (See "U.S. Research Facilities of Foreign Firms" for a summary of recent statistics on foreign R&D sites in the United States.) Firms tend to adopt a global approach to R&D for one of two basic reasons:

1. Multinational firms seek a foreign R&D presence to support their overseas manufacturing facilities or to adapt standard products to the demand there. This arrangement constitutes a *home-base exploiting* site, where information tends to flow to the foreign laboratory from the central home laboratory.
2. The foreign site is established to tap knowledge from competitors and universities around the globe, constituting a *home-base augmenting* site, where information tends to flow from the foreign laboratory to the central home laboratory.

According to a recent study of 238 foreign R&D sites, 45 percent of the labs were home-base augmenting and 55 percent were home-base exploiting (Kuemmerle 1997).[61]

Figure 4-32.
Interregional alliances as a share of world total strategic alliances, by technology



NOTE: Interregional alliances include those between the United States and Europe, the United States and Japan, and Europe and Japan.

See appendix table 4-48. *Science & Engineering Indicators – 1998*

U.S.-Foreign Industrial R&D Flows

U.S. companies' R&D investment abroad is *roughly* equivalent to R&D expenditures in the United States by majority-owned U.S. affiliates of foreign companies.[62] In 1994 (the latest year for which complete data from the Bureau of Economic Analysis—BEA—are available), industrial R&D flows into the United States totaled $12.7 billion, compared with the $11.5 billion in R&D expenditures by U.S. multinational firms in other countries. (See figure 4-33.) This approximate balance in R&D investment flows has persisted since 1989 when the majority-owned data first became available on an annual basis. However, a general shift has occurred in the aggregate "balance" of R&D flows over this period. In the early 1990s, a greater proportion of international R&D was spent abroad than was invested in the United States. It now appears the reverse is true, and more industrial R&D money is flowing into the United States than U.S. firms are investing abroad.

Europe is both the primary source and the main destination of these U.S.-foreign industrial R&D flows. (See figure 4-34.) European firms invested $11.6 billion of R&D money in the United States in 1995; the Asian (including the Middle East) and Pacific region provided the second largest source of foreign R&D funds, with $1.6 billion. Similarly, U.S. companies invested $8.3 billion of R&D in Europe and $1.9 billion in Asian and Pacific region investments. Bilateral R&D

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[61] The terms "home-base exploiting" and "home-base augmenting" are taken directly from Kuemmerle (1997). However, others (notably Mowery 1997) have made similar observations on the reasons for the expanding global R&D arrangements. Furthermore, Mowery notes that the use of international R&D strategies to establish networks for the creation and strengthening of firm-specific technological capabilities (that is, home-base augmenting) is likely to become more important than market exploitation-driven activities in the future.

[62] These overseas R&D data are from the U.S. Bureau of Economic Analysis (BEA) survey on U.S. Direct Investment Abroad. The definition used by BEA for R&D expenditures is from the Financial Accounting Standards Board Statement No. 2; these expenditures include all charges for R&D performed for the benefit of the affiliate by the affiliate itself and by others on contract. BEA detail is available for 1982 and annually since 1989. Data on foreign sources of industrial R&D performed in the United States come from an annual survey of Foreign Direct Investment in the United States, also conducted by BEA. BEA reports that foreign R&D totals are comparable with U.S. R&D business data published by NSF. Industry-specific comparisons, however, are limited because of differences in the industry classifications used by the two surveys (Quijano 1990).

U.S. Research Facilities of Foreign Firms

Consistent with the worldwide trend of multinational firms establishing an R&D presence in multiple countries, considerable growth has occurred in R&D facilities being operated by foreign companies in the United States. According to a 1992 survey of 255 foreign-owned free-standing R&D facilities in the United States, about half were established during the previous six years (Dalton and Serapio 1993). These counts are only for those R&D facilities that are 50 percent or more owned by a foreign parent company.* In a recent update to this study (Dalton and Serapio 1998), the authors characterize the activities of 676 U.S. R&D facilities run by more than 350 European, Japanese, and other foreign companies. Significant findings of this study follow:

- R&D facilities owned by Japanese firms continue to far outnumber those of all other countries. Japanese companies owned 244 R&D facilities in the United States in 1996, British companies owned 102, German companies owned 93, and French and Swiss companies each owned more than 40. (See text table 4-10.) South Korean companies have a rapidly growing presence in the United States, owning 32 R&D facilities here in 1996—6 more than had been identified in 1994, and about 20 more than listed for 1992.
- The activities of these foreign facilities were highly concentrated in several industries: drugs and biotechnology (111 facilities), chemicals and rubber (110), computers and computer software (88), food and consumer goods (61), high-definition television and other electronics (59), instruments and medical devices (52), and automotive products (50). Japanese companies account for most of the R&D centers in the electronics and automotive industries, while European companies have far more R&D sites focusing on pharmaceuticals and chemicals.
- Foreign R&D facilities were heavily concentrated in selected areas of the country, notably California's Silicon Valley and greater Los Angeles, Detroit, Boston, Princeton, and North Carolina's Research Triangle Park.

The most important reasons cited for Japanese foreign electronics R&D investment in the United States were to acquire technology and to keep abreast of technological developments (a home-base augmenting strategy). For automotive R&D, investment motives centered on assisting the parent company in meeting U.S. environmental regulations and customer needs (a home-base exploiting strategy).

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*An R&D facility typically operates under its own budget and is located in a free-standing structure outside of and separate from the parent's other U.S. facilities (e.g., sales and manufacturing). This definition of an R&D facility consequently excludes R&D departments or sections within U.S. affiliates of foreign-owned companies.

Text table 4-10.
U.S. R&D facilities of foreign companies, by selected industry and country: 1996

Industry	Total	Japan	United Kingdom	Germany	France	Switzerland	South Korea	Netherlands	Canada	Other
Total	676	244	102	93	44	42	32	30	20	69
Computers	39	22	1	2	0	0	7	2	5	0
Software	49	34	8	2	0	0	1	1	2	1
Semiconductors	32	18	0	2	0	0	10	2	0	0
Telecommunications	35	17	3	4	2	1	0	1	7	0
Opto-electronics	19	9	3	2	0	0	0	0	0	5
HDTV, other electronics	59	32	9	7	3	1	5	1	1	0
Drugs, biotechnology	111	26	15	24	6	19	2	5	0	14
Chemicals, rubber	110	23	18	27	14	7	1	6	4	10
Metals	23	8	5	2	0	1	0	2	2	3
Automotive	50	31	1	8	2	0	4	2	0	2
Machinery	27	5	6	3	4	2	0	0	1	6
Instrumentation, medical devices	52	6	20	6	3	6	0	3	2	6
Food, consumer goods	61	11	11	4	1	9	1	9	4	11

HDTV = high-definition television

NOTE: Sum of industry details may not add up to country totals because of cross-industry R&D at facilities.

SOURCE: D.H. Dalton and M.G. Serapio, Jr., *Globalizing Industrial Research and Development* (Washington, DC: U.S. Department of Commerce-Technology Administration, 1998).

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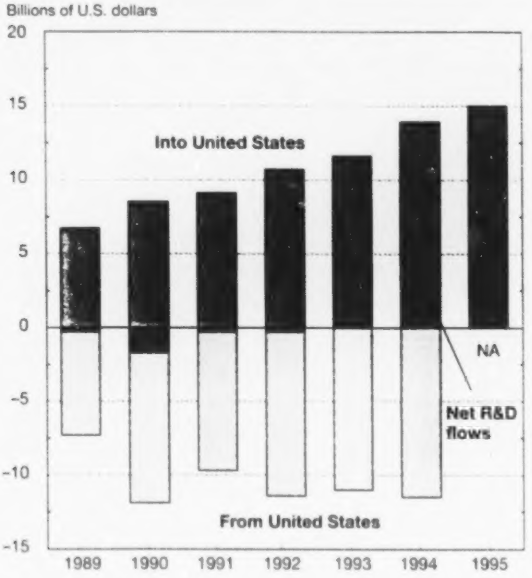
Figure 4-33.
Balance in U.S. and foreign industrial R&D investment flows



NA = not available

See appendix tables 4-51 and 4-53.

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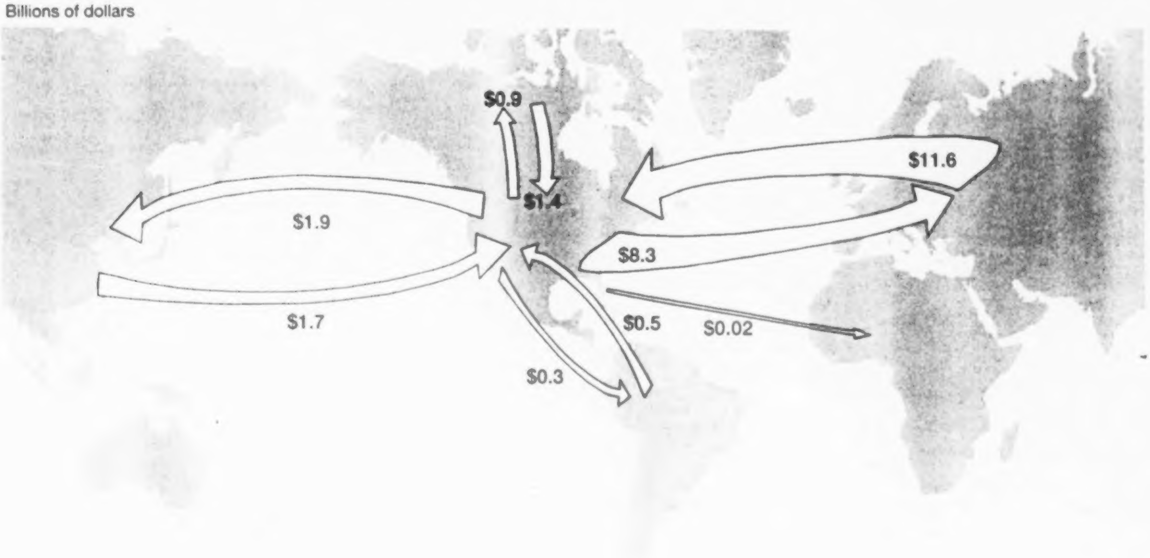
investments between Canada and the United States are in the $1 billion to $1.4 billion range. R&D flows remain small to negligible both into and out of Latin America and Africa.

U.S. Industry's Overseas R&D

Since 1985, U.S. firms generally increased their annual funding of R&D performed outside the country. (See appendix table 4-50.) Indeed, from 1985 to 1995, U.S. firms' investment in overseas R&D increased three times faster than did company-funded R&D performed domestically (10.1 versus 3.4 percent average annual constant-dollar growth). Industries' total R&D performance, including funding from federal sources, grew at a meager 1.4 percent annual rate over the 1985-95 period. Equivalent to about 6 percent of industry's domestic R&D funding in 1985, overseas R&D now accounts for 12 percent of U.S. industry's on-shore R&D expenditures.[63] (See figure 4-35.) Additionally, according to BEA data, the majority-owned (that is, 50 percent or more) foreign-affiliate share of U.S. multinational companies' worldwide R&D expenditures increased from 9 percent in 1982 to 13 percent in 1990, where it remained through 1994 (Mataloni and Fahim-Nader 1996).

Figure 4-34.
U.S. flows of industrial R&D, by world region



NOTE: R&D flows from the United States are for 1994 and R&D flows into the United States are for 1995.

See appendix tables 4-51 and 4-53.

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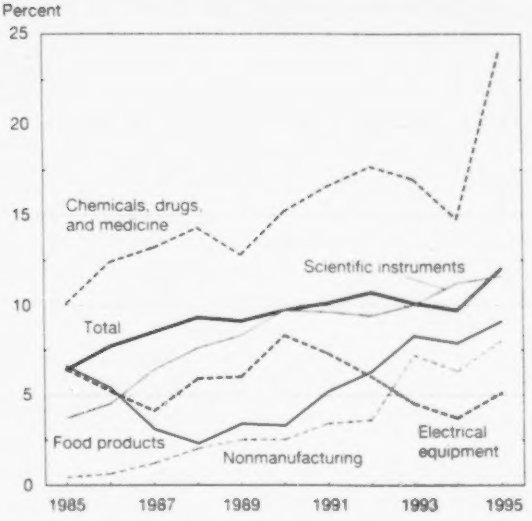
[63] These overseas R&D shares are taken from the NSF industrial R&D data series, not the BEA Direct Investment Abroad series used in the "International R&D Investment Balance" discussion. However, BEA data on the country destination of the U.S. overseas R&D investment are more complete than the NSF series and therefore are used to describe country patterns. NSF reports 1994 and 1995 overseas R&D totals of $9.4 billion and $13.1 billion, respectively; BEA estimates 1994 overseas R&D expenditures by U.S. companies and their foreign affiliates at $11.5 billion.

Figure 4-35.
Ratio of U.S. overseas R&D to company-financed domestic R&D, by industry



See appendix table 4-50. *Science & Engineering Indicators – 1998*

Lion's Share for Chemicals Industry. R&D investment by U.S. companies and their foreign subsidiaries in the chemicals (including pharmaceuticals and industrial chemicals) industry accounts for the largest share and greatest growth of foreign-based R&D activity. Indeed, drug companies accounted for 20 percent of total 1995 overseas R&D ($2.6 billion of the $13.1 billion total)—equivalent to 25 percent of the pharmaceutical industry's domestically financed R&D. (See appendix table 4-50.) Of other major R&D-performing manufacturers, recent trends show the overseas R&D investment share of total R&D financing rising considerably for scientific instruments and the food industry.

Increased R&D Activity in Nonmanufacturing Industries. Similarly, the combined total for all nonmanufacturing industries shows substantial increases in foreign R&D activity since 1985, rising from 0.4 percent of domestic R&D funding that year to 8.0 percent in 1995. Part of this growth reflects increased international R&D financing by firms historically classified as nonmanufacturing industries (particularly computer, data processing, and architectural services). Part of the increase reflects the movement of firms previously classified as manufacturers (e.g., office computing companies) to service sector industries (e.g., software development).

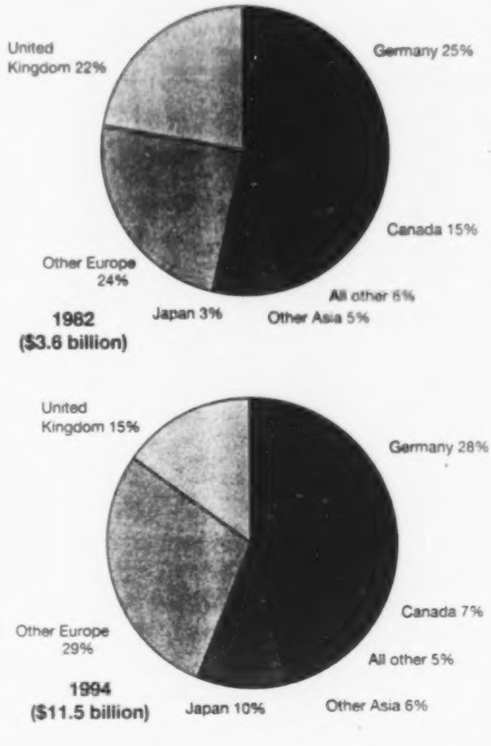
Most R&D Performed in Europe, Though Shifting East. As indicated by BEA data on majority-owned foreign affiliates of nonbank U.S. multinational companies, most of the U.S. 1994 overseas R&D was performed in Europe—primarily Germany (28 percent of the U.S. overseas total), the United Kingdom (15 percent), France (11 percent), and Ireland (4 percent). (See figure 4-36 and appendix table 4-51.) Collectively, however, the current 72 percent European share of the U.S. total R&D investment abroad is somewhat less than the 78 percent share reported as recently as 1990. Since the early 1980s, U.S. R&D investments abroad have generally shifted away from the larger European countries and Canada, and toward Japan and other Asian countries.

By affiliate industry classification, more than one-half of the 1994 German-based R&D was performed by transportation equipment companies. In the United Kingdom and France, the chemicals industry accounted for the largest share of each countries' respective totals, whereas in Ireland, the machinery industry performed most of this U.S.-funded R&D. In Japan, which accounted for 10 percent of U.S. companies' 1994 R&D performed abroad, the largest share was performed in chemicals firms' foreign affiliates. (See text table 4-11.) Notably, the U.S. R&D investment in Asian countries other than Japan has grown substantially; for example, U.S. R&D spending in Singapore (primarily in machinery industries) now surpasses that in many European nations.

Foreign R&D in the United States

Like U.S. firms' overseas R&D funding trends, R&D activity by foreign-owned companies in the United States has increased significantly since the mid-1980s. From 1987 to 1995, inflation-adjusted R&D growth from foreign firms (U.S.

Figure 4-36.
U.S. R&D performed abroad



See appendix table 4-51. *Science & Engineering Indicators – 1998*

Text table 4-11.

R&D performed overseas by majority-owned foreign affiliates of U.S. parent companies, by selected region/country and industry of affiliate: 1994

(Millions of dollars)

		Manufacturing					
Region/country	All industries	Total	Chemicals	Machinery	Electrical equipment	Transportation equipment	Nonmanufacturing
Total	12,097	10,147	3,119	2,034	797	2,812	1,950
Canada	861	D	226	34	D	272	D
Europe	8,791	D	2,204	1,600	D	2,309	D
Belgium	516	373	344	3	2	4	143
France	1,357	1,142	543	202	D	D	215
Germany	2,808	2,630	296	530	128	1,435	178
Ireland	462	435	87	292	43	0	27
Italy	409	382	189	93	26	30	27
Netherlands	418	345	63	12	163	5	73
Switzerland	191	D	10	8	D	0	D
United Kingdom	2,179	1,938	616	433	D	D	241
Rest of Europe	451	D	56	27	D	D	D
Asia and Pacific	1,856	1,381	D	381	D	68	475
Australia	230	D	40	D	1	D	D
Japan	1,123	787	397	77	136	6	336
Singapore	238	225	2	195	27	0	13
Taiwan	110	D	D	D	D	D	D
Western Hemisphere	481	465	197	14	22	164	16
Brazil	239	235	50	5	14	D	4
Mexico	185	182	115	9	7	D	3
Middle East	94	D	D	5	D	0	D
Africa	15	14	10	1	*	*	1

* = less than $500,000; D = withheld to avoid disclosing operations of individual companies

NOTES: Includes direct investments of majority-owned nonbank foreign affiliates of U.S. parents. Includes R&D expenditures conducted by the foreign affiliates for themselves or for others under a contract. Bureau of Economic Analysis expenditures differ from National Science Foundation-reported expenditures in appendix table 4-50.

SOURCE: U.S. Bureau of Economic Analysis, *U.S. Direct Investment Abroad: Operations of U.S. Parent Companies and Their Foreign Affiliates* (Washington, DC: U.S. Government Printing Office, 1997).

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affiliates with a foreign parent that owns 50 percent or more of the voting equity) averaged 12.5 percent per year.[64] This growth contrasts quite favorably with the implied 3 percent average annual rate of real increase in U.S. firms' domestic R&D funding, and is almost 10 times the 1.3 percent 1987-95 growth rate of total domestic industrial R&D performance (including activities funded by foreign firms and the Federal Government). As a result of these various funding trends, foreign R&D was equivalent to 11 percent ($15 billion) of total industrial R&D performance in the United States in 1995—or more than double that of its equivalent 5 percent share in 1987. Majority-owned affiliates accounted for just a 3 percent share of the U.S. 1980 industrial performance total. (See figure 4-37.)

Most R&D Flows From Five Countries. The geographic pattern of R&D flows into the United States differs from the trends noted for U.S. R&D spending abroad. Whereas countries other than G-7 countries have become increasingly important as a destination for U.S. funding, they are less important in terms of foreign R&D investments here. In 1995, 75 percent of foreign funding came from just five countries—Germany, Switzerland, the United Kingdom, France, and Japan. In 1980, firms from these five countries accounted for 62 percent of foreign R&D flows into the United States. Although the R&D flows from Canada and other European countries also increased steadily over the past 15 years, at least part of the significant expansion of foreign R&D ex-

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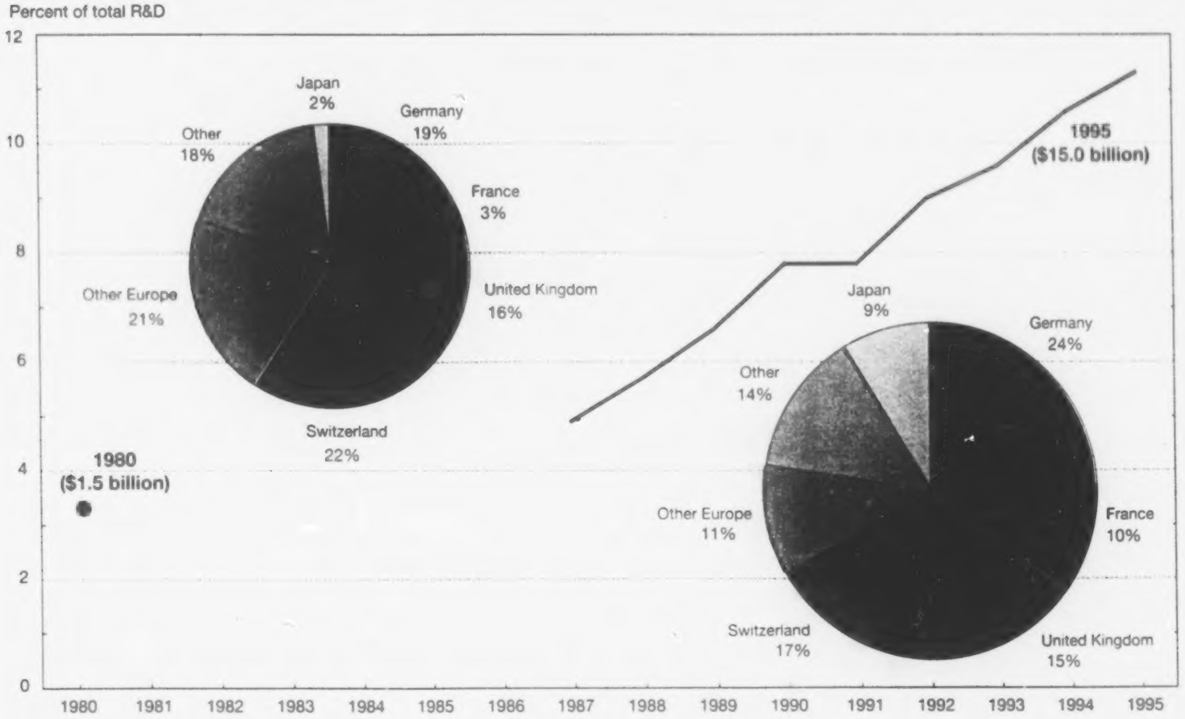
[64] Although BEA considers all of an investment (including R&D) to be foreign if 10 percent or more of the investing U.S.-incorporated firm is foreign-owned, special tabulations were prepared by BEA to reveal R&D expenditures in the United States of those firms in which there is majority foreign ownership of 50 percent or more. For 1995, the 10 percent foreign ownership threshold results in an estimated $17.7 billion foreign R&D investment total. (See appendix table 4-52.) R&D expenditures of majority-owned U.S. affiliates of foreign companies were $15 billion. (See appendix table 4-53.) Tabulations for the majority-owned firms' R&D financing are used for most of the analyses provided here; the sole exception is the use of foreign R&D data at the 10 percent threshold for review of country-specific funding patterns for individual industrial sectors. (See text table 4-12.) Such data for majority-owned affiliates are not available.

Figure 4-37.
U.S. industrial R&D financed by majority-owned foreign firms: Share of total and sources of funds



NOTE: Data are not available for 1981-86.

See appendix table 4-53.

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penditures is attributable to several major acquisitions by foreign multinational companies of U.S. firms, particularly of U.S. pharmaceutical and biotechnology firms with large R&D budgets.

Research Concentrated in Three Industries. Foreign-funded research was concentrated in three industries in 1995—drugs and medicines (mostly from Swiss and British firms), industrial chemicals (funded predominantly by German firms), and electrical equipment (one-third of which came from French affiliates).[65] These three industries accounted for three-fifths of the $17.7 billion total 1995 foreign R&D investment by affiliates in which there was at least 10 percent foreign ownership. Concurrent with gains reported for all domestic U.S. R&D performance, foreign—particularly Japanese—R&D investment in the service sector was also significant. These industries accounted for 5 percent ($900 million) of the 1995 foreign R&D investment total, with most research being funded in computer, data processing, and research and management services. (See text table 4-12.)

Summary

There was a resurgence in R&D investment in the United States in the mid-1990s. A prosperous economy has invigorated companies in both the manufacturing and service sectors, enabling them to allocate more resources toward the discovery of new knowledge and the application of that knowledge in the development of new products, processes, and services. An upsurge in innovation is further contributing to a buoyant economy.

At the same time that the private sector's role in maintaining the health of U.S. R&D enterprise has been expanding, the Federal Government's contribution has been receding, as the federal share has become less prominent in both the funding and the performance of R&D. As a result of these two divergent funding trends, the composition of the nation's R&D investment is slowly shifting. For example, recently, a growing percentage of the nation's R&D total has been directed toward nondefense activities. While industry has focused its R&D on new product development, the Federal Government historically has been the primary funding source for basic research activities.

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[65] Totals are for R&D expenditures for U.S. affiliates of firms in which there is 10 percent or more foreign ownership. (See previous footnote.)

Text table 4-12.
R&D performed in the United States by affiliates of foreign companies, by selected region/country and industry of affiliate: 1995
(Millions of dollars)

		Manufacturing								
Region/country	All industries	Total	Drugs & medicines	Other chemicals	Machinery	Electrical equipment	Transportation equipment	Instruments	Service industries[a]	Other industries[b]
Total	17,666	14,743	5,255	3,071	1,089	2,770	478	682	922	2,001
Canada	1,396	1,320	*	24	13	D	D	D	18	58
Europe	13,370	11,926	5,167	2,962	584	1,482	316	506	557	887
France	1,844	1,594	——579——		127	424	52	106	35	215
Germany	3,976	3,676	759	2,026	——583——		144	45	38	262
Netherlands	838	609	1	303	*	D	7	D	35	194
Switzerland	3,088	2,688	2,268	47	89	110	*	D	351	49
United Kingdom	2,419	2,178	——1,420——		94	103	83	206	80	161
Asia and Pacific	2,435	1,228	77	78	467	D	D	48	339	868
Japan	1,867	1,052	70	60	389	192	39	38	323	492
Western Hemisphere	280	148	0	*	3	3	1	D	3	129
Middle East	98	D	11	0	10	D	0	6	5	D
Africa	68	D	0	0	2	0	0	0	*	D

* = less than $500,000; D = withheld to avoid disclosing operations of individual companies

NOTES: Not all countries and industries are shown. Includes foreign direct investments of nonbank U.S. affiliates only. Includes R&D expenditures conducted by and for the foreign affiliates. Excludes expenditures for R&D conducted for others under a contract. Expenditures differ from Bureau of Economic Analysis-reported expenditures in appendix table 4-53.

[a] Includes computer and data processing services ($402 million) and accounting, research, and management services ($456 million).

[b] Includes wholesale trade ($1,412 million) and petroleum ($387 million).

SOURCE: U.S. Bureau of Economic Analysis, *Foreign Direct Investment in the United States: Operations of U.S. Affiliates of Foreign Companies Preliminary 1995 Estimates* (Washington, DC: U.S. Government Printing Office, 1997).

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Although more positive than negative indicators of the health of R&D funding have appeared in recent years, there is some cause for concern that short-term R&D may be displacing the longer term quest for new knowledge and breakthrough discoveries. To compensate for what may be a recession in long-term fundamental research, new trends have been emerging. Greater reliance is being placed on the academic research community, and all sectors have expanded their participation in a variety of domestic and international partnerships both within and across sectors. The rapid rise in global R&D investments is evident from the expansion of industry's overseas R&D spending and the even more rapid rise in foreign firms' R&D spending in the United States. These domestic and foreign collaborations permit performers to pool and leverage resources, reduce costs, and share the risks associated with research activities. In addition, such alliances and international investments open a host of new scientific opportunities for R&D performers, enabling them to accelerate the exploration and deployment of promising new research and technologies that undoubtedly will be the source of tomorrow's new products and services.

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Chapter 5

Academic Research and Development: Financial and Personnel Resources, Integration With Graduate Education, and Outputs

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Highlights

FINANCIAL RESOURCES FOR ACADEMIC R&D

- **In 1997, an estimated $23.8 billion (in current dollars) was spent for research and development (R&D) at U.S. academic institutions ($21.1 billion in constant 1992 dollars).** The Federal Government provided $14.2 billion; academic institutions, $4.4 billion; state and local governments, $1.8 billion; and industry and other sources each provided $1.7 billion.

- **Industrially performed R&D grew faster than academic R&D between 1994 and 1997,** and the academic sector's share fell to 12 percent, reversing a decade-long trend of an increasing role for academic performers in total U.S. R&D. Between 1984 and 1994, academia had risen from a 9 percent share to a 13 percent share of total U.S. R&D performance.

- **The academic sector performs over 50 percent of basic research, continuing to be the largest performer of basic research in the United States.** Academic R&D activities are concentrated at the basic research end of the R&D spectrum. Of estimated 1997 academic R&D expenditures, an estimated 67 percent went for basic research, 25 percent for applied research, and 8 percent for development.

- **The Federal Government continues to provide the majority of funds for academic R&D.** It provided an estimated 60 percent of the funding for R&D performed in academic institutions in 1997, down from about 65 percent in the early 1980s. Although nonfederal support increased more rapidly than federal through most of the 1980s, this trend was reversed in the first half of the 1990s. Federal support has grown more slowly than nonfederal in both 1996 and 1997, however.

- **Federal obligations for academic R&D are concentrated in three agencies: the National Institutes of Health (NIH—57 percent), the National Science Foundation (NSF—15 percent), and the Department of Defense (DOD—10 percent).** The National Aeronautics and Space Administration (6 percent), the Department of Energy (5 percent), and the Department of Agriculture (3 percent) provide an additional 14 percent of obligations for academic R&D. Federal agencies emphasize different science and engineering (S&E) fields in their funding of academic research. Several agencies concentrate their funding in one field; others have more diversified funding patterns.

- **There has been a significant increase in the number of universities and colleges receiving federal R&D support during the past two decades,** with almost the entire increase occurring among other than research and doctorate-granting institutions. In 1995, 654 of these institutions received R&D support from the Federal Government, compared to 422 in 1985 and 335 in 1975.

- **After the Federal Government, the academic institutions performing the R&D provided the second largest share of academic R&D support.** The institutional share grew from about 14 percent of academic R&D expenditures in the early 1980s to an estimated 19 percent in 1997. Some of these funds directed by the institutions to research activities derive from federal and state and local government sources, but—since they are not restricted to research and the universities decide how to use them—they are classified as institutional funds.

- **Industrial R&D support to academic institutions has grown more rapidly than support from all other sources in recent years.** In constant dollars, industry-financed academic R&D increased by an estimated average annual rate of 8.1 percent between 1980 and 1997. Industry's share grew from 4 percent to an estimated 7 percent during this period.

- **Total academic S&E research space increased by almost 22 percent between 1988 and 1996,** up from about 112 million to 136 million net assignable square feet. When completed, construction projects initiated between 1986 and 1995 are expected to produce 52 million square feet of new research space, equivalent to about 39 percent of existing space.

- **In 1996, 55 percent of research-performing institutions reported construction or repair/renovation projects that were needed but had to be deferred because funds were not available.** The cost of these deferred projects was $9.3 billion. Sixty percent of the needs reported were for construction and 40 percent were for repair/renovation.

- **Expenditures for academic research instrumentation in U.S. research universities began increasing recently.** This increase follows a pattern of large increases in investment throughout most of the 1980s, followed by a steady decline of about 2 percent a year between 1989 and 1993. Annual research equipment expenditures as a percentage of total R&D expenditures declined from 7.2 percent in 1986 to 5.2 percent in 1993 before rising again to 5.6 percent in 1995.

- **Computers and data handling equipment represented 19 percent of the number of instruments in the national stock and 30 percent of total aggregate cost.** There were an estimated 61,684 instruments with an estimated aggregate original purchase price of $6.255 billion in the stock of research instruments at the 318 colleges, universities, and medical schools represented in the National Survey of Academic Research Instruments and Instrumentation Needs in 1993.

THE ACADEMIC DOCTORAL S&E WORKFORCE

- ◆ **The 217,500 academic doctoral scientists and engineers in 1995 represented the largest number ever employed in the academic sector.** But employment growth for this highly trained group was stronger in other parts of the economy, and the academic sector's employment share stood at 46 percent—a record low.
- ◆ **Full-time doctoral S&E faculty numbered an estimated 171,400 in 1995, a decline from 173,100 in 1991.** Full-time faculty represented 79 percent of academic doctoral S&E employment in 1995, down from 88 percent in 1973. Much of the decline occurred among those with the rank of full professor.
- ◆ **The number of women with S&E doctorates who held academic positions increased to 52,400 in 1995.** This represented a new high to 24 percent of total academic employment of doctoral scientists and engineers. Women remained highly concentrated in the life and social sciences and psychology.
- ◆ **Minority employment continued to grow and reached 35,300 in 1995, but stayed at low levels for some groups.** The 12,800 members of underrepresented groups—black, Hispanic, Native American, and Alaskan Native—accounted for 6 percent of academic doctoral scientists and engineers, up from 2 percent in 1973. Asian employment in 1995 stood at 22,500, or 10 percent of the total; this was up from 4 percent in 1973.
- ◆ **Women and members of minority groups have tended to enter academic employment in line with or above their proportion of recently awarded S&E doctorates.** Among recent Ph.D. recipients in academic employment—doctorates awarded in the preceding three years—women and underrepresented minorities were employed in rough proportion to their share of newly awarded doctorates to U.S. citizens and permanent visa-holders; Asians—many of whom are foreign-born—were represented well in excess of their share of new S&E Ph.D.s.
- ◆ **The progressive aging of the doctoral academic S&E workforce, evident over much of the past two decades, appears to have leveled off.** The mean age of full-time doctoral faculty rose from 42.5 years in 1973 to 47.1 years in 1989 and stood at 47.4 years in 1995, suggesting gradual hiring for the system as a whole as faculty retire. However, for young Ph.D.s, this has to be seen in the context of a steep increase in newly awarded doctorates—from about 22,700 in 1989 to 27,800 in 1995.
- ◆ **An estimated 26,900 recent Ph.D. recipients—doctorates awarded in 1992-94—entered academic employment in 1995. But the meaning of academic "employment" has changed for these young doctorate-holders.** Fewer than 45 percent had regular faculty appointments, compared with over 75 percent in the early 1970s, while the proportion in postdoctorate positions rose from 13 to 40 percent.
- ◆ **The physical sciences have grown more slowly than other fields in terms of overall doctoral employment—29,300 in 1995—and doctorates in full-time faculty positions.** Their doctoral employment share fell from 19 percent in 1973 to 13 percent in 1995. The life sciences, engineering, and psychology gained employment shares.

WORK RESPONSIBILITIES OF ACADEMIC DOCTORAL SCIENTISTS AND ENGINEERS

- ◆ **The academic doctoral S&E research workforce—defined as those whose primary or secondary work responsibility was research—numbered an estimated 153,500 in 1995, up from 80,000 to 90,000 during the 1970s.** The highest levels of research participation, so defined, were found in engineering and the environmental sciences; the lowest in mathematics, psychology, and the social sciences.
- ◆ **In 1995, 39 percent of the academic doctoral workforce—85,700—reported having research support from the Federal Government during the week of April 15.** This compares with 37 percent in 1993. A sizable fraction of those with federal funding—26 percent—obtained their support from more than one agency.
- ◆ **The number of those reporting teaching as their primary activity has fluctuated around the 100,000 mark since 1985. In contrast, those designating research as primary rose from 56,000 to 83,000 over the period.** In 1995, 46 percent of respondents reported teaching as their primary work responsibility, compared with 38 percent who reported research.
- ◆ **Doctoral S&E employment growth in Carnegie research universities was largely confined to those identifying research as their primary activity**—from 17,500 in 1973 to 45,900 in 1995. In other types of institutions, the number choosing research grew from 10,300 to 37,100 over the period.

Integration of Research With Graduate Education

- **In 1995, for the first time in almost two decades, enrollment of full-time S&E graduate students declined slightly.** The enrollment decline was irrespective of primary source of support. The numbers of full-time graduate students with primary support from the Federal Government, nonfederal sources, or their own resources (self-support) all declined.
- **The proportion of full-time graduate students in S&E with a research assistantship as their primary mechanism of support has increased considerably.** Research assistantships were the primary support mechanism for 66 percent of the students whose primary source of support was from the Federal Government in 1995, compared to 55 percent in 1980. For students whose primary source was nonfederal, research assistantships rose from 20 percent to 29 percent of the total during this period. The overall number of graduate students with a research assistantship as their primary mechanism of support increased every year between 1985 and 1994 before declining slightly in 1995.
- **The Federal Government plays a larger role as the primary source of support for some support mechanisms than for others.** A majority of traineeships in both private and public institutions (53 and 73 percent, respectively) are financed primarily by the Federal Government, as are 60 percent of the research assistantships in private and 47 percent in public institutions.
- **NIH and NSF have been the primary source of federal support for full-time S&E graduate students relying on research assistantships as their primary support mechanism.** From the early 1970s to the late 1980s, NSF was the federal agency that was the primary source for graduate research assistantships. It was surpassed by NIH in 1993. Between 1972 and 1995, the proportion of federal graduate research assistantships financed primarily by NSF declined from one-third to less than one-quarter, while the proportion financed primarily by NIH increased from one-sixth to one-quarter.
- **Research assistantships are more frequently identified as a primary mechanism of support in the physical sciences, the environmental sciences, and engineering than in other disciplines.** Research assistantships comprise more than 50 percent of the primary support mechanisms for graduate students in astronomy, atmospheric sciences, oceanography, agricultural sciences, chemical engineering, and materials engineering. They account for less than 20 percent in the social sciences, mathematics, and psychology.

Article Outputs From Scientific and Engineering Research

- **In 1995, about 142,800 scientific and technical articles were published by U.S. authors in a set of journals included in the Science Citation Index (SCI) since 1981. The bulk—71 percent—were by academic authors.** Eight percent each had authors affiliated with other major sectors: industry, government, and nonprofit organizations.
- **Publications by U.S. industrial authors rose strongly in life science fields—clinical medicine, biomedical research, and biology—and constituted nearly half of industry publications; this was up from 19 percent in 1991.** From the late 1980s on, industry output in engineering and technology was lower than it had been in preceding years.
- **Increasingly, scientific collaboration in the United States involves scientists and engineers from different employment sectors. In 1995, just under one-quarter of all academic papers involved such cross-sectoral collaboration**—6 percent with industry, 8 percent each with the federal and not-for-profit sectors, 3 percent with federally financed research and development centers, and 2 percent with other sectors. In the other sectors, well over half of their cross-sector collaborations involved academic authors.
- **Globally, five nations produced more than 60 percent of the 439,000 articles in the SCI set of journals in 1995:** the United States (33 percent), Japan (9 percent), the United Kingdom (8 percent), Germany (7 percent), and France (5 percent). No other country's output reached 5 percent of total.
- **The development or strengthening of national scientific capabilities in several world regions was evident in faster publications output growth elsewhere than in the United States; growth elsewhere accelerated toward the mid-1990s, overshadowing continued growth in U.S. output.** This continued a long-term decline in the U.S. share of total article output.
- **Europe accrued gains in output share—from 32 percent in 1981 to 35 percent in 1995. Asia's share rose from 11 to 15 percent,** even though India's output declined by one-third in absolute number of articles over the period.
- **The number of articles in physics, earth and space sciences, and biomedical research increased the most rapidly—by 63, 36, and 30 percent, respectively—from 1981 to 1995.** The output volume of articles in chemistry, clinical medicine, and engineering and technology was little changed; those for mathematics and biology declined.

- **Great variation marked countries' article outputs per billion U.S. dollars of their estimated 1995 gross domestic product.** Israel and some smaller European nations ranked highest, exceeding 30 articles per billion. The United States was in the middle range, with 20 articles. Nations with fast-developing economies had smaller than expected article outputs, reflecting the recent rapidity of their economic strides and suggesting considerable room for further scientific growth.
- **Countries' science portfolios, as reflected in their published output, show some striking differences.** Clinical medicine and biomedical research are heavily emphasized in the article outputs of the United States, United Kingdom, the countries of Northern Europe, several smaller Western European nations, and Chile. Chemistry and physics form a larger than average fraction of the output of France, Germany, Spain, Italy, Eastern Europe, Russia, Mexico, and many Asian countries. Russia, China, Egypt, and Asian countries emphasize engineering and technology.

INTERNATIONAL COLLABORATION AND CITATION OF RESEARCH OUTPUTS

- **The globalization of science is reflected in a pervasive trend in scientific publishing toward greater collaboration. In 1995, half of the articles in the SCI journals had multiple authors, and almost 30 percent of these involved international collaboration.** This trend affected all fields, and a steadily growing fraction of most nations' papers involved coauthors from different nations. By 1995, article outputs since 1981 had grown by 20 percent, the number of coauthored articles by 80 percent, and the number with international coauthors by 200 percent.
- **For almost every nation with strong international coauthorship ties, the *number* of articles involving a U.S. author rose strongly between 1981 and 1995.** Concurrently, however, many nations broadened the reach of their international collaborations, causing a diminution of the U.S. *share* of the world's internationally coauthored articles.
- **Citation patterns also mirror the global nature of the scientific enterprise, as researchers everywhere extensively cite research outputs from around the world.** U.S. scientific and technical articles as a whole are cited by virtually all mature scientific nations in excess of the U.S. output's world share. This holds for chemistry, physics, biomedical research, and clinical medicine. U.S. articles in other fields tend to be cited at or slightly below their world output share.
- **The number of article citations on U.S. patents increased from 8,600 in 1987 to 47,000 in 1996, and their field distribution shifted strongly toward the life sciences.** This rise in number of citations held for all fields and for papers from all sectors, with the fastest growth in citations to biomedical research and clinical medicine.
- **The number of academic patents, while small, rose more than sevenfold in just over two decades—from about 250 annually in the early 1970s to more than 1,800 in 1995—and the number of academic institutions receiving patents increased from about 73 in the early 1980s to 168 by the mid-1990s.** Academic patenting increased more rapidly than all annual U.S. patent awards. Among institutions with patents are a growing number of universities and colleges not traditionally counted among the research universities.
- **Academic patents are concentrated in fewer utility classes than patents overall; in fact, patents in only three utility classes with presumed biomedical applicability constituted more than a quarter of all academic patents in 1995.** Revenue from academic patenting reached $299 million in 1995.

Introduction

Chapter Background

The academic research and development (R&D) enterprise has enjoyed strong growth for the past decade but is facing some issues arising partly from its own success, partly from changes in its environment.

The nation's universities and colleges continue to perform more than half of U.S. basic research. Though faced with severe financial pressures, their own R&D funds are nearing one-fifth of their total R&D expenditures. At the same time, industry relies increasingly on academic R&D. There is more collaboration between industrial and academic researchers, and patent citing to academic publications is increasing. Industry support has grown, but remains well below 10 percent of the total funding of research in academia; furthermore, industry funding cannot be expected to become a mainstay of academic research funding.

The Federal Government continues to provide the majority of academic R&D support. Three agencies provide the bulk of these funds—the National Institutes of Health (NIH), the National Science Foundation (NSF), and the Department of Defense (DOD). NSF and DOD together provide much of the nation's R&D support for the physical and computer sciences, mathematics, and engineering.

Demographic projections point to the potential for strong enrollment growth over the next decade and the continuation of several trends: more minority participation, more older students, more nontraditional students. Foreign graduate students, however, may attend U.S. institutions in lesser numbers.[1] In this context, and driven by financial and other pressures, universities and colleges will continue to debate questions about their focus and mission. These discussions will take place against the backdrop of faculty retirements. An unresolved question is the extent and nature of replacement hiring into tenure-track faculty positions versus other, more temporary, appointments.

Urgent questions about the nature of graduate education are being raised. Is the current model the appropriate one, or should training allow for broader and more varied application of skills in the marketplace? Should students be given more autonomy from their professors, perhaps by way of restructuring their modes of support? What is the appropriate role for the Federal Government in this support? Continued increases in the number of foreign students, vital for many graduate programs, cannot be taken for granted. Thus, issues about the nature of graduate education join with questions of university missions and program organization.

The research universities are valued as a national resource. They educate and train large proportions of the nation's scientists and engineers, embody the model of integrated graduate training and research, and conduct much of the nation's basic research. Yet they face difficult questions. Is the nature of their graduate training up to the task of developing a high-quality yet flexible workforce of scientists and engineers? Is it driven too much by research? Is their research enterprise too insular, too driven by its own dynamic or external demands from the Federal Government or industry? Does it cost too much? How can research be better connected to undergraduate education? Other universities increasingly face these same questions, as the growth of the research function continues in institutional segments that have not traditionally been considered among the research universities.

Answers to these and other questions will emerge gradually, as individual institutions respond to the challenges and opportunities they perceive. The nation's universities and colleges have shown great ability to adapt to changed realities. In time, it will become possible to take stock of the changes and assess their extent. Many issues underlying these changes will persist, as higher education institutions try to find the appropriate balance among their many functions. (See "Developments Impinging on Academia.")

This chapter addresses several key aspects of the academic R&D enterprise including financial resources, physical infrastructure, science and engineering (S&E) doctoral employment, the integration of research and graduate education, and research outputs. The questions raised in the preceding discussion are difficult ones to resolve and relate to highly complex issues. This chapter, while not providing definitive answers to these questions, does provide data trends and analysis to assist decisionmakers in assessing these issues.

Chapter Organization

The chapter opens with a discussion of trends in the financial resources provided for academic R&D, including allocations across both academic institutions and S&E fields. Since the Federal Government has been the primary source of support for academic R&D for over half a century, the importance of selected agencies in supporting individual fields is explored in some detail. Data are also presented on changes in the number of academic institutions receiving federal R&D support. The section next examines the status of two key elements of university research activities—facilities and instrumentation. Topics explored include their funding, adequacy, and unmet needs.

The next section discusses trends in the employment, demographic characteristics, and activities of academic doctoral scientists and engineers. The discussion of employment trends focuses on full-time faculty and other positions. Trends in the involvement of women, underrepresented minorities, and Asians are explored, as are shifts in the faculty age structure. Special attention is given to participation in research by academic doctoral scientists and engineers and the federal support reported for these activities. Selected demographic characteristics of recent doctorate-holders entering academic employment are examined.

The third section looks at the relationships between research and graduate education. It covers overall trends in graduate support and patterns of support in different types of institutions, and compares support patterns for those who

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[1] For a discussion of this point, see chapter 2, "Foreign Doctoral Students in the United States."

Developments Impinging on Academia

The nation's universities and colleges are facing changes in finances, enrollment, faculty, and environment whose eventual results cannot be foreseen with any degree of confidence. Cost pressures seem unabated; state funding to public institutions may benefit from a strong economy but faces competition from other uses. Overall enrollment in the nation's four-year colleges and universities declined somewhat in the early 1990s after rising during the preceding decade. However, the U.S. Department of Education projects rising numbers of students at U.S. universities and colleges over the coming decade or more, based on demographic projections and assumptions about cohort participation rates in higher education. The available evidence suggests that the racial/ethnic makeup of the student body will continue to change, and that women will continue to make inroads into fields that they have not traditionally entered. The number of foreign students, long a mainstay for many graduate programs in science and engineering, may decline as other countries develop their own programs. Faculty retirements are expected to rise, based on the age structure; but institutions' responses to this situation are not clear. Replacement hiring may take place, or some portion of the teaching burden may be shifted to temporary or nonfaculty employees. Media-based teaching and learning developments might affect the roles of teachers and of higher education institutions—and might perhaps even affect enrollments. State governments are looking at universities as regional economic development engines and sources of innovation, and the institutions themselves pay increasing attention to these types of activities.

Current discussions about university roles, structures, and priorities will need to take account of these and other factors. It is difficult to predict with any degree of precision the course of any one of these factors, much less their combined impacts on the future shape of the U.S. higher education enterprise as set in an increasingly skill-based society.

complete an S&E doctorate with the full population of graduate students. The extent of participation by graduate research assistants in academic research is examined, as are the sources of support for research assistants and the spreading incidence of research assistantship (RA) support to a growing number of academic institutions.

The chapter's final section deals with two research outputs: scientific and technical articles in a set of journals covered by the Science Citation Index (SCI), and patents issued to U.S. universities. (A third major output of academic R&D, educated and trained personnel, is discussed in the preceding section of this chapter and in chapter 2.) The section specifically looks at the output volume of research (article counts), collaboration in the conduct of research (joint authorships), use in subsequent scientific activity (citation patterns), and use beyond science (citations to the literature on patent applications).

Financial Resources for Academic R&D[2]

Adequate financial support for R&D activities at U.S. universities and colleges, as well as excellent research facilities and high-quality research equipment, is essential in enabling U.S. academic researchers to carry out world-class research. Since academic R&D is a significant part of the national R&D enterprise, this section focuses both on the levels and sources of support for R&D activities at U.S. universities and colleges as well as academic R&D facilities and instrumentation.

Overview[3]

In 1997, an estimated $23.8 billion was spent on R&D at U.S. academic institutions.[4] Academia's role as an R&D performer increased steadily between 1984, when this sector accounted—as it had for more than a decade—for just 9 percent of all R&D performed in the country, and 1994, when it performed almost 13 percent of all U.S. R&D. (See figure 5-1.) By 1997, the sector's performance share had dipped to just below an estimated 12 percent.

Character of Work

Academic R&D activities are concentrated at the research (basic and applied) end of the R&D spectrum and do not include much development activity.[5] Of 1997 academic *R&D*

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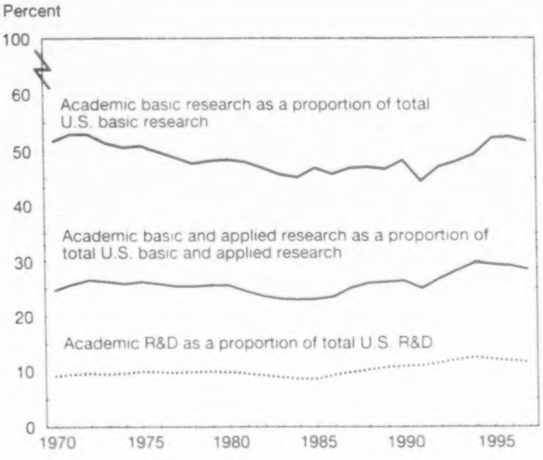
[2] Data in this section come from several different National Science Foundation surveys; these do not always use comparable definitions or methodologies. NSF's three main surveys involving academic R&D are (1) the Federal Funds for Research and Development Survey; (2) the Federal Support to Universities, Colleges, and Selected Nonprofit Institutions Survey; and (3) the Scientific and Engineering Expenditures at Universities and Colleges Survey. The results from this last are based on data obtained directly from universities and colleges; the former two surveys collect data from federal agencies. For descriptions of the methodologies of these and other NSF surveys, see NSF (1995b and 1995c). Federally funded research and development centers associated with universities are tallied separately and are examined in greater detail in chapter 4.

[3] This discussion is based on data in NSF (1996b) and unpublished tabulations. For more information on national R&D expenditures, see chapter 4, "National R&D Spending Patterns."

[4] Academic institutions generally comprise institutions of higher education that grant doctorates in science or engineering and/or spend at least $50,000 for separately budgeted R&D.

[5] Notwithstanding this delineation, the term "R&D"—rather than just "research"—is used throughout this discussion unless otherwise indicated, since almost all of the data collected on academic R&D do not differentiate between "R" and "D." Moreover, it is often difficult to make clear distinctions among basic research, applied research, and development. For the definitions used in NSF resource surveys, see chapter 4.

Figure 5-1.
Academic R&D, research, and basic research as a proportion of U.S. totals

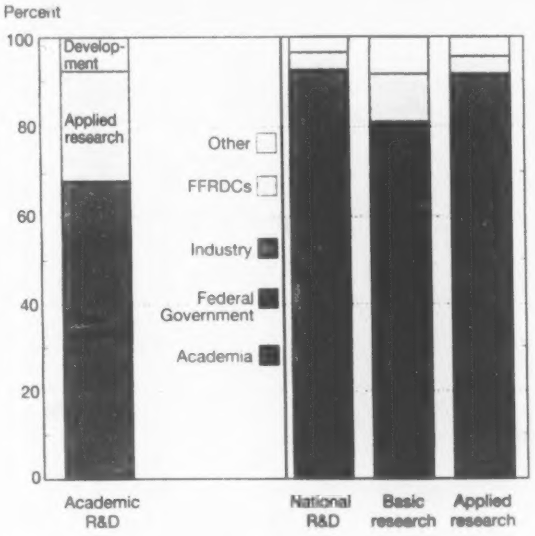


NOTE: Data for 1996 and 1997 are estimates.

See appendix tables 4-4, 4-5, and 4-6.

Science & Engineering Indicators – 1998

Figure 5-2.
National and academic R&D expenditures, by character of work and performer: 1997



NOTE: Data are estimates. FFRDCs are federally funded research and development centers.

See appendix tables 4-4, 4-5, 4-6, and 5-1.

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expenditures, an estimated 67 percent went for basic research, 25 percent for applied research, and 8 percent for development. (See figure 5-2.) From a national *research*—as opposed to national R&D—perspective, academic institutions accounted for between 23 and 30 percent of the U.S. total during the past three decades. In terms of *basic research* alone, the academic sector is the country's largest performer, accounting for between 44 and 53 percent of the national total during the past three decades. (See figure 5-1.)

Growth

Average annual R&D growth between 1984 and 1994 (in constant 1992 dollars) was much stronger for the academic sector than for any other R&D-performing sector—5.7 percent, compared to about 4.2 percent for other nonprofit laboratories, 1.5 percent for industrial laboratories, 0.6 percent for federally funded research and development centers (FFRDCs), and zero growth for federal laboratories. Since 1994, this growth has slowed to an estimated 1.6 percent annually; however, this rate is still higher than for any other R&D-performing sector but industry (which grew at an estimated 6.2 percent annually). As a proportion of gross domestic product (GDP), academic R&D rose from 0.23 to 0.30 percent between 1984 and 1997.

Funding Sources

The Federal Government continues to provide the majority of funds for academic R&D. In 1997, it accounted for an estimated 60 percent of the funding for R&D performed in academic institutions. Nevertheless, the federal support share is declining fairly steadily, down from 68 percent in 1980 and 71 percent in 1970. (See figure 5-3.) Until the beginning of the 1990s, support from other sectors grew more rapidly than did that from the Federal Government. This trend reversed in the early 1990s, with federal support growing faster than nonfederal through 1995. Federal support is estimated to grow more slowly than nonfederal in both 1996 and 1997. The federal sector primarily supports basic research—71 percent of its 1997 funding went to basic research versus 20 percent to applied. Nonfederal sources provide a larger share of their support for applied research (61 percent for basic and 32 percent for applied research).

Federal support of academic R&D is discussed in detail later in this section; the following summarizes the contributions of other sectors to academic R&D.[6]

- **Institutional funds.** Institutional funds are separately budgeted funds that an academic institution spends on R&D from unrestricted sources, unreimbursed indirect costs associated with externally funded R&D projects, and mandatory and voluntary cost sharing on federal and other grants. These constitute the second largest source of aca-

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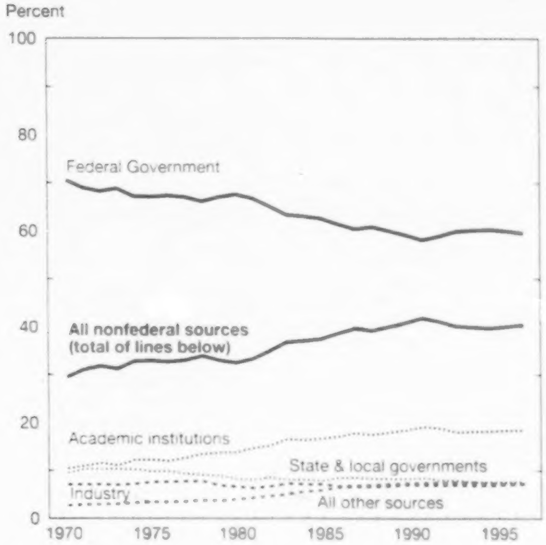
[6] The academic R&D funding reported here only includes separately budgeted R&D and institutions' estimates of unreimbursed indirect costs associated with externally funded R&D projects, including mandatory and voluntary cost sharing. It does not include departmental research, and thus will exclude funds—notably for faculty salaries—in cases where research activities are not separately budgeted.

Figure 5-3.
Sources of academic R&D funding



NOTE: Data for 1996 and 1997 are estimates.

See appendix table 5-2. *Science & Engineering Indicators – 1998*

demic R&D funding. The share of support represented by institutional funds has been increasing fairly steadily since 1980, save for a brief downturn in 1992 and 1993. In 1980, institutional funds accounted for about 14 percent of all academic R&D expenditures; the estimated 1997 share is about 19 percent.[7] The major sources of institutional R&D funds are (1) general-purpose state or local government appropriations, particularly for public institutions; (2) general-purpose grants from industry, foundations, or other outside sources; (3) tuition and fees; (4) endowment income; and (5) gifts that are not restricted by the donor to research. Other potential sources of institutional funds are income from patents or licenses and income from patient care revenues. (See "Income From Patenting and Licensing Arrangements" later in this chapter; also see "Academic Research and the Changing U.S. Health Care System" for a discussion of how the level and nature of research at medical schools may be affected by changes in the U.S. health care system.)

- **State and local government funds.** The share of academic R&D funding provided by state and local governments fluctuated slightly around the 8 percent level between 1980 and 1991, and declined steadily to just above 7 percent in 1994 before beginning a (slight) increase back up toward an estimated 8 percent in 1997. This share, however, only reflects funds directly targeted to academic R&D activities and does not include general-purpose state or local government appropriations that are used for separately budgeted research or to cover unreimbursed indirect costs. Consequently, the actual contribution of state and local governments to academic R&D is understated, particularly for public institutions.

- **Industry funds.** The funds provided for academic R&D by the industrial sector, although they account for the smallest share of funding, grew faster than did funding from any other source during the past two decades. Industry increased its share from slightly below 3 percent in 1970, to about 4 percent in 1980 and about 7 percent in 1990, where it has since remained. Industry's contribution to academia represented an estimated 1.3 percent of all industry-funded R&D in 1997, compared to 0.8 percent in 1980 and 0.6 percent in 1970. In the past two years, however, this relative contribution has declined slightly from its peak of 1.5 percent in 1994. "Industry-University Ties and the Conduct and Dissemination of Academic Research" touches on some of the concerns raised by industry funding of academic R&D, particularly its impact on the nature of university research and the dissemination of research findings.

- **Other sources of funds.** Other sources of support include grants for R&D from nonprofit organizations and voluntary health agencies and gifts from private individuals that are restricted by the donor to research, as well as all other sources restricted to research purposes not included in the other categories. Since 1986, this source of academic R&D support has stayed fairly constant at about 7 percent.

Funding by Institution Type

Patterns of sectoral funding of academic R&D vary depending on the type of academic institution involved. That is, the importance of different funding sources varies for both private and public universities. (See appendix table 5-3.) For all *public* academic institutions combined, just under 10 percent of R&D funding in 1995—the most recent year for which data are available—came from state and local funds, about 23 percent from institutional funds, and about 54 percent from the Federal Government. *Private* academic institutions received about 2 percent of funds from state and local governments, 9 percent from institutional sources, and 73 percent from the Federal Government. Both public and private institutions received approximately 7 percent of their respective R&D support from industry in 1995. Over the past two decades, the federal share of support has declined, and the industry and institutional shares have increased, for both public and private institutions.

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[7] Some of the growth in institutional R&D funds may be due to accounting changes, including both a shift of departmental research to separately budgeted research and increased institutional ability to calculate unreimbursed indirect costs, including mandatory and voluntary cost sharing. Available data suggest, however, that it is unlikely that this accounts for the bulk of the increase. Growth in institutional R&D funds has been roughly in line with growth in academic institutions' total operating expenditures over the past two decades. Growth has also been steady over the entire time period, without the sudden shifts that would be expected if better or significantly different reporting were to occur simultaneously in a large number of institutions.

Academic Research and the Changing U.S. Health Care System

Clinical revenues generated by medical school faculty have traditionally been used to support undergraduate and graduate medical education and research at U.S. medical schools. These revenues are also thought to be a major source of support for younger researchers, who often have difficulty obtaining external grants. In a study for the American Association of Medical Colleges Task Force on Medical School Financing (Jones and Sanderson 1996), it is estimated that clinical revenues generated by medical school faculty to support core academic programs totaled $2.4 billion in 1993. The major beneficiary of this support ($816 million) was found to be research, followed by undergraduate medical education ($702 million) and graduate medical education ($594 million). Jones and Sanderson note that hospitals may also provide clinical support for academic missions by applying hospital funds to academic programs and by absorbing academic program expenses that are not otherwise reimbursed. However, changes in the U.S. health care system—particularly the emergence of managed care, the growing consolidation of health care providers, and increased price competition—are believed to be adversely affecting both the level and nature of research at medical schools. For example, two recent studies (Moy et al. 1997; and Campbell, Weissman, and Blumenthal 1997) suggest that faculty members at U.S. medical schools might be conducting less clinical research because of pressure on their institutions to cut costs and raise revenues. They show that in regions where managed care plans are dominant and where there is stiff competition for dollars and patients among hospitals, physicians at academic medical centers report more pressure to take care of patients—and thus conduct fewer human studies, do less clinical research, and publish fewer papers.

The main finding of the Moy study is that medical schools in all markets had comparable rates of growth in NIH awards from 1986 to 1990, but that between 1990 and 1995, medical schools in markets with high managed care penetration had slower growth in the dollar amount and number of awards compared with schools in markets with medium or low managed care penetration. The authors conclude that their results "provide evidence of an inverse relationship between growth in NIH awards during the last decade and managed care penetration among U.S. medical schools," although they do state that it remains to be determined whether the association is causal. One of the findings of the Campbell study is that clinical researchers in less competitive health care markets published more scientific articles than those in more competitive health care markets. Another finding is that a significantly larger proportion of young faculty members had patient care duties in more competitive markets than in less competitive markets. The authors conclude that "increased competitiveness of health care markets seems to hinder the capacity of academic health centers to conduct clinical research and to foster the careers of young clinical faculty."

These findings raise questions as to where the funds for clinical research that might be lost due to the changing health care market are to come from in the future, as well as the patients to participate in clinical research experiments.

Distribution of R&D Funds Across Academic Institutions[8]

Most academic R&D is now, and has been historically, concentrated in relatively few of the approximately 3,600 higher education institutions in the United States.[9] In fact, if all such institutions were ranked by their 1995 R&D expenditures, the top 200 institutions would account for about 94 percent of R&D expenditures. In 1995:

- the top 10 institutions spent 17 percent of total academic R&D funds ($3.7 billion),
- the top 20 institutions spent 29 percent ($6.5 billion),
- the top 50 spent 55 percent ($12.10 billion), and
- the top 100 spent 78 percent ($17.2 billion).[10]

This historic concentration of funds, however, has diminished somewhat during the past decade. In 1985, the top 10 institutions received about 19 percent of the funds. The decline in this group's share is approximately matched by the increase in the share of those institutions in the group below the top 100—this group's share increased from 19 to 22 percent of total academic R&D funds. The institutions ranked from 11 to 100 received similar shares in 1995 as in 1985 (between 61 and 62 percent). (See appendix table 5-4.)

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[8] The Carnegie Foundation for the Advancement of Teaching classified about 3,600 degree-granting institutions as higher education institutions in 1994. (See chapter 2, "Characteristics of U.S. Higher Education Institutions," for a brief description of the Carnegie categories.) These higher education institutions include four-year colleges and universities, two-year community and junior colleges, and specialized schools such as medical and law schools. Not included in this classification scheme are more than 7,000 other postsecondary institutions (secretarial schools, auto repair schools, etc.)

[9] See Geiger and Feller (1995) for an interpretation of the patterns of dispersion of academic research funds among universities.

[10] These percentages exclude the Applied Physics Laboratory (APL) at the Johns Hopkins University. With an estimated $447 million in total expenditures and $434 million in federally financed expenditures in fiscal year 1995, APL performs about 57 percent of the university's R&D. Although not officially classified as an FFRDC, APL essentially functions as one. Its exclusion therefore provides a better measure of the distribution of academic R&D dollars and the ranking of individual institutions.

Expenditures by Field and Funding Source[11]

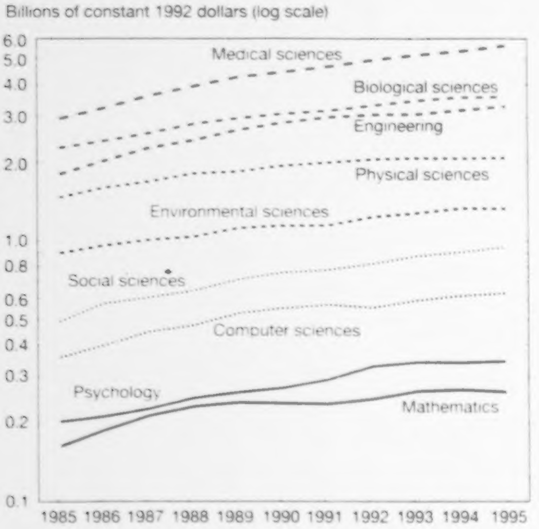
The overwhelming share of academic R&D expenditures in 1995 went to the life sciences, which accounted for 55 percent of total academic R&D expenditures, 53 percent of federal academic R&D expenditures, and 57 percent of nonfederal academic R&D expenditures. Within the life sciences, medical sciences accounted for 27 percent of total academic R&D expenditures and biological sciences for 17 percent. The next largest block of total academic R&D expenditures was for engineering—16 percent in 1995. (See appendix table 5-5; for detailed data on expenditures over time by S&E field, see appendix table 5-6.)

Between 1985 and 1995, academic R&D expenditures for all fields combined grew at an average annual rate of 5.2 percent in constant 1992 dollars. (See figure 5-4.) Funding for the social sciences grew fastest during the decade, increasing at an average annual rate of 6.8 percent in constant dollars. Within the social sciences, political science was the fastest growing fine field (8.1 percent) and economics the slowest growing (4.2 percent). Engineering grew second fastest, increasing at an average annual rate of 6.2 percent. Within engineering, aeronautical/astronomical and civil engineering grew the fastest (7.5 percent and 7.4 percent, respectively) and electrical engineering the slowest (5.5 percent). Academic R&D expenditure growth was slowest in the physical sciences, averaging 3.6 percent. Within the physical sciences, physics and chemistry grew the slowest (2.5 percent and 2.9 percent, respectively) and astronomy the fastest (8.8 percent). All other S&E fields averaged rates of annual growth between 4 and 6 percent.

The distribution of federal and nonfederal funding of academic R&D in 1995 varied by field. (See appendix table 5-5.) For example, the Federal Government supported about 78 percent of academic R&D expenditures in both physics and atmospheric sciences, but only 32 percent of academic R&D in economics and 30 percent in the agricultural sciences.

The declining federal share in support of academic R&D is not limited to particular S&E disciplines. Rather, the federally financed fraction of support for *each* S&E field was lower in 1995 than in 1975. (See appendix table 5-7.) The most dramatic decline occurred in the social sciences (55 percent in 1975 to 39 percent in 1993); the smallest declines were in the computer sciences and environmental sciences (74 to 70 percent and 71 to 67 percent, respectively). The overall decline in federal share also holds for all the reported S&E fine fields except the agricultural sciences (which increased slightly from 29 to 30 percent). Many fields have experienced slight increases in federal share during the first half of the 1990s.

Figure 5-4.
Academic R&D expenditures, by field



NOTE: See appendix table 4-1 for GDP implicit price deflators used to convert current dollars to constant 1992 dollars.

See appendix table 5-6. *Science & Engineering Indicators – 1998*

Federal Support of Academic R&D

Top Agency Supporters

Federal obligations for academic R&D are concentrated in three agencies: the National Institutes of Health, the National Science Foundation, and the Department of Defense. Together, these agencies are estimated to have provided approximately 82 percent of total federal financing of academic R&D in 1997, as follows:

- NIH—57 percent,
- NSF—15 percent, and
- DOD—10 percent.

An additional 14 percent of the 1997 obligations for academic R&D are provided by the National Aeronautics and Space Administration (NASA, 6 percent); the Department of Energy (DOE, 5 percent); and the Department of Agriculture (USDA, 3 percent). (See appendix table 5-8.) Federal obligations for academic research are concentrated similarly to those for R&D. (See appendix table 5-9.)There are some differences, however, since some agencies place greater emphasis on development (DOD), while others place greater emphasis on research (NSF).

During the 1990s, NASA's funding of academic R&D increased most rapidly, with an estimated average annual growth rate of 3.1 percent per year in constant 1992 dollars. The next highest rates of growth were experienced by NIH (2.7 percent) and NSF (1.9 percent). Between 1996 and 1997, total federal obligations for federal R&D are estimated to decline in constant dollars. Only NSF (by 3 percent) and DOE

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[11] The data in this section are drawn from NSF's Scientific and Engineering Expenditures at Universities and Colleges Survey. For various methodological reasons, parallel data by field from the NSF Survey of Federal Obligations to Universities and Colleges do not necessarily match these numbers.

Industry-University Ties and the Conduct and Dissemination of Academic Research

Growing industry support of academic R&D and expanding industry-university ties have given rise to two concerns: that universities' commitment to basic research may be undermined, and that free and open disclosure of academic research results may face restrictions. In a chapter in *Challenge to the Research University*, Wesley M. Cohen and coauthors Richard Florida, Lucien Randazzese, and John Walsh (1998) examine these issues in light of recent research. Key hypotheses and research results are summarized here.

A number of indicators suggest that industry-university research relations have indeed expanded substantially since the mid-1970s. The industry share of academic R&D has more than doubled during that time. In 1990, 1,056 university-industry R&D centers—nearly 60 percent of them established during the 1980s—spent $2.9 billion on R&D. Patenting at the top 100 research universities expanded from 177 awards in 1974 to 1,486 in 1994; 200 offices administered technology transfer and licensing activities in 1990, compared with 25 in 1980. The authors also cite anecdotal evidence of an increase in spinoffs or faculty participation in new firms, along with increasing equity shares held by universities in firms spun off to commercialize academic research outputs.

Different incentives motivate firms and universities to form these partnerships. University initiatives led to the establishment of almost three-quarters of the university-industry research centers—61 percent originating with faculty, 12 percent with administrators.

The authors hypothesize that firms' profit incentive may incline them to control access to results of research they have sponsored and that it may also focus them on applied rather than basic research. This conflicts with academics' priority—the free and open publication and dissemination of their research findings, which is the source of academic eminence and the basis for further scientific inquiry. Thus, widespread industry-university collaborations may induce shifts toward more applied academic research and restricted disclosure of academic research findings. Others have suggested that firms may shift some of their internal fundamental research to academia.

Cohen, Florida, Randazzese, and Walsh provide some evidence for their hypotheses. On the issue of restricted access to research results, 53 percent of a national sample of university-industry research centers allowed firms to request publication delays; 35 percent permitted deleting of information prior to submission for publication (Cohen, Florida, and Goe 1994). For 117 centers whose missions most strongly supported an orientation toward industry needs, these numbers were higher: publication delays, 63 percent; deletion of information, 54 percent. Moreover, study respondents reported restrictions on faculty communications with faculty and staff at the home university (21 percent), with those at other universities (29 percent), and with the general public (42 percent). These numbers are about 15 percentage points higher for centers strongly oriented toward industry needs. Cohen, Florida, Randazzese, and Walsh note, however, that although publication and communications restrictions may be contained in agreements, they are not necessarily always implemented. They also indicate that implementation of such restrictions may undermine key channels through which academic research affects industrial R&D.

Similarly, in a sample of companies supporting academic life science research, 82 percent stipulated that research results could be kept confidential pending a patent application; 47 percent had agreements permitting at least occasional embargo of results beyond the patent application (Blumenthal et al. 1996). In a survey of academic technology managers, 39 percent reported having agreements that placed restrictions on faculty sharing information regarding R&D breakthroughs with departmental or other center faculty. In that study, 79 percent of the technology managers and 53 percent of faculty with experience in interacting with firms indicated that firms had asked for R&D results to be delayed or kept from publication (Rahm 1995). Cohen, Florida, Randazzese, and Walsh note that the existence of spinoff companies raises the same set of questions and speculate that similar pressures may apply to the composition and disclosure of research—the main difference being that they would be generated by the faculty, rather than externally.

The evidence regarding a displacement of basic by applied research is less clear. Several studies have found an empirical association between greater faculty-industry interaction and more applied research (Rahm 1994, Morgan 1993 and 1994); another survey found that stronger center mission focus on improving industry activities was associated with lower shares of center effort going toward basic research (Cohen, Florida, and Goe 1994). However, while acknowledging the difficulty of drawing a boundary between basic and applied research, Cohen, Florida, Randazzese, and Walsh note that university-reported NSF data on the composition of academic R&D fail to reflect a shift away from basic research, which constituted 67 percent of academic R&D during 1980-83 and 66 percent during 1990-93. They point out that industry support may be attracting faculty already inclined toward applied research, rather than inducing others to shift away from basic research.

(by 0.5 percent) are expected to increase their academic R&D obligations in 1997.

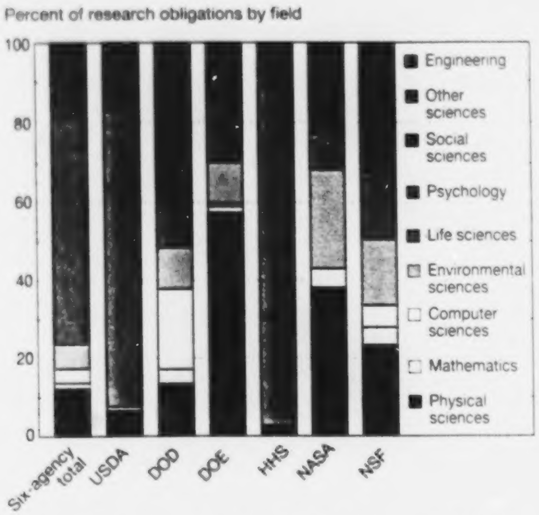
Agency Support by Field

Federal agencies emphasize different S&E fields in their funding of academic research. Several agencies concentrate their funding in one field—the Department of Health and Human Services (HHS) and USDA focus on the life sciences, while DOE concentrates on the physical sciences. Other agencies—NSF, NASA, and DOD—have more diversified funding patterns. (See figure 5-5.) Even though an agency may place a large share of its funds in one field, it may not be an important contributor to that field, particularly if it doesn't spend much on academic research. (See figure 5-6.) NSF is the lead funding agency in the physical sciences (34 percent of total funding), mathematics (53 percent), and the environmental sciences (47 percent). DOD is the lead funding agency in the computer sciences (60 percent) and in engineering (38 percent). HHS is the lead funding agency in the life sciences (85 percent), the social sciences (41 percent), and psychology (86 percent). Within S&E fine fields, other agencies take the leading role—DOE in physics (46 percent), USDA in agricultural sciences (99 percent) and economics (75 percent), and NASA in astronomy (68 percent) and in both aeronautical (60 percent) and astronautical (64 percent) engineering.

The Spreading Institutional Base of Federally Funded Academic R&D[12]

Despite fluctuations over the past couple of decades, the number of academic institutions receiving federal support for their R&D activities has increased, rising from 555 in 1975, to 648 in 1985, and to 882 in 1995.[13] (See text table 5-1.) Since most research and doctorate-granting institutions were already receiving federal support in 1975, almost the entire increase has occurred among comprehensive; liberal arts; two-year community, junior, and technical; and professional and other specialized schools. The number of such institutions receiving federal support has just about doubled over the 1975-95 period, rising from 335 in 1975, to 422 in 1985, and to 654 in 1995. These institutions are also receiving a larger share of the reported federal obligations for R&D to universities and colleges now than in the past—11 percent in 1995, compared to 7 percent in 1985.

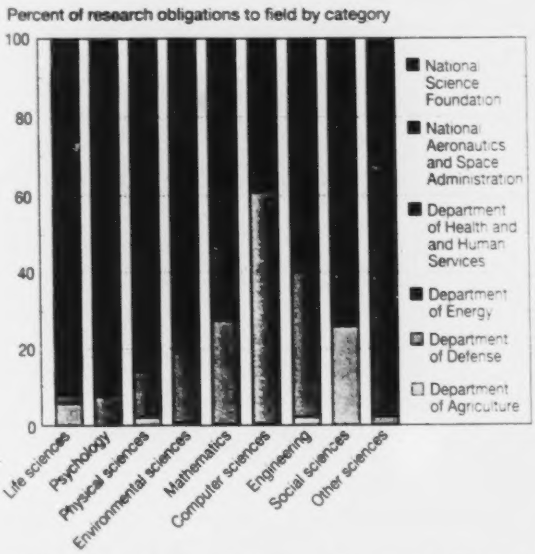
Figure 5-5.
Distribution of federal agency academic research obligations, by field: FY 1995



USDA = Department of Agriculture; DOD = Department of Defense; DOE = Department of Energy; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation
NOTE: The six agencies reported represent approximately 96 percent of federal academic research obligations.

See appendix table 5-10. *Science & Engineering Indicators – 1998*

Figure 5-6.
Major agency field shares of federal academic research obligations: FY 1995



NOTE: The six agencies reported represent approximately 96 percent of federal academic research obligations.

See appendix table 5-11. *Science & Engineering Indicators – 1998*

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[12] The data in this section are drawn from NSF's Federal Support to Universities, Colleges, and Selected Nonprofit Institutions Survey. The survey collects data on federal R&D obligations to individual U.S. universities and colleges from the 15 federal agencies that account for virtually all such obligations. For various methodological reasons, data reported in this survey do not necessarily match those reported in the Scientific and Engineering Expenditures at Universities and Colleges Survey.

[13] See NSB (1993) for a more comprehensive discussion of the spreading institutional base, which includes developments in individual S&E fields. The field analysis cannot be extended after 1993 because DOD no longer provides detailed academic R&D funding by field.

Text table 5-1.
Number of academic institutions receiving federal R&D support

	All academic institutions	Research and doctorate-granting institutions[a]	Other institutions[a]
1975	555	220	335
1985	648	226	422
1990	746	227	519
1994	890	227	663
1995	882	228	654

[a]These are the institutional categories used by the Carnegie Foundation for the Advancement of Teaching. See chapter 2, "Characteristics of U.S. Higher Education Institutions," for information on these categories. "Other institutions" are all Carnegie-classified institutions except research and doctorate-granting institutions.

SOURCES: National Science Foundation, Science Resources Studies Division, *Federal Support to Universities, Colleges, and Nonprofit Institutions, Fiscal Year 1995*, Detailed Statistical Tables, forthcoming (Arlington, VA: 1998); and unpublished tabulations.

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Recently, legislation has been passed that requires federal agencies to demonstrate the impact of their programs. See "GPRA: Instituting Accountability in Federal Funding of Academic R&D" for a discussion of how this legislation hopes to improve federal planning and management, increase accountability for and assessment of results, and provide better information for congressional and agency decisionmaking.

Academic R&D Facilities and Instrumentation[14]

Facilities Overview[15]

Total Space. Between 1988-89 and 1996-97, total academic science and engineering research space increased by almost 22 percent, from about 112 million to 136 million net assignable square feet (NASF).[16] (See appendix table 5-12.) Planned construction expenditures for academic research facilities are expected to reach $3.1 billion (in constant dollars) in 1996-97.[17] If this planned funding materializes, it will reverse the recent downward trend that began between 1990-91 and 1992-93. Construction expenditures in constant dollars peaked at around $3.4 billion in 1990-91, dropped to $3.0 billion in 1992-93, and dropped again to $2.8 billion in 1994-95. (See appendix table 5-13.)

New Construction. New construction projects initiated between 1986 and 1995 were expected to produce over 52 million square feet of research space when completed—the equivalent of about 39 percent of estimated existing research space. A significant portion of this new research space likely replaces obsolete or inadequate space rather than actually increases existing space: this is indicated by the fact that the total amount of research space increased by 24 million NASF between 1988-89 and 1996-97, while new construction initiated between 1988-89 and 1994-95 was expected to increase by 43 million NASF. Planned new construction projects initiated in 1996-97 are expected to produce just under 11 million square feet of new research space. (See appendix table 5-12.)

Repair and Renovation. Planned expenditures for major repair/renovation (i.e., projects costing over $100,000) of academic research facilities are expected to reach $1.3 billion (in constant dollars) in 1996-97. These expenditures also increased between 1992-93 and 1994-95, rising from $905 million to $1.1 billion in constant dollars. (See appendix table 5-13.) While expenditures for major repair/renovation increased between 1992-93 and 1994-95, expenditures for smaller S&E research facility repair/renovation projects (those costing less than $100,000) decreased—dropping during this period from $261 million to $135 million in constant dollars. Projects initiated between 1986 and 1995 were expected to result in the repair/renovation of over 55 million square feet of research space.[18] Planned projects initiated in 1996-97 are expected to result in the repair/renovation of an additional 13.7 million square feet of research space. (See appendix table 5-12.)

Repair/renovation expenditures as a proportion of total capital expenditures (construction and repair/renovation) have increased steadily since 1990-91, rising from 25 percent of all capital project spending to 30 percent by 1994-95. Forty-three percent of all research-performing colleges and universities are planning to undertake some type of repair/renovation costing over $100,000 during 1996-97; 29 percent are planning to undertake construction projects during the same period.

Sources of Funds. Since 1986, there have been some shifts in the significance of various funding sources for the construction and repair/renovation of S&E research space. While the relative rankings of these sources have remained fairly

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[14] Data on facilities and instrumentation are taken primarily from several NSF-supported surveys. Although terms are defined specifically in each survey, in general facilities expenditures (1) are classified as "capital" funds, (2) are fixed items such as buildings, (3) often cost millions of dollars, and (4) are not included within R&D expenditures as reported here. Equipment and instruments (the terms are used interchangeably) are generally movable, purchased with current funds, and included within R&D expenditures. Because the categories are not mutually exclusive, some large instrumentation systems could be classified as either facilities or equipment.

[15] The information in this section is derived from NSF's biennial Survey of Scientific and Engineering Research Facilities at Universities and Colleges. For more detailed data and analysis on academic S&E research facilities (for example, by institution type and control), see NSF (1996c).

[16] "Research space" here refers to the net assignable square footage of space within facilities (buildings) in which S&E research activities take place. Multipurpose space within those facilities, such as an office, is prorated to reflect the proportion of use devoted to research activities. NASF data are reported for combined years (e.g., 1987-88 data are for fiscal years 1987 and 1988.

[17] Current dollars have been adjusted to 1995 constant dollars using the U.S. Bureau of the Census's Composite Fixed-Weighted Price Index for Construction.

[18] It is difficult to report repaired/renovated space in terms of a percentage of existing research space. As collected, the data do not differentiate between repair and renovation, nor do they provide an actual count of unique square footage that has been repaired or renovated. Thus, any proportional presentation might include double or triple counts, since the same space could be repaired (especially) or renovated several times.

GPRA: Instituting Accountability in Federal Funding of Academic R&D

In response to the Clinton Administration's effort to move toward a government that works better and costs less, Congress passed the Government Performance and Results Act of 1993 (GPRA). GPRA aims to shift the focus of federal agencies away from traditional concerns such as staffing and the level of services provided and toward *results*. Specifically, GPRA looks to improve federal planning and management, increase accountability for and assessment of results, and provide better information for congressional and agency decisionmaking. To accomplish these and related goals, GPRA requires every federal agency to prepare detailed, multiyear strategic plans; annual performance plans; and annual performance reports. These documents give agencies formal tools with which to set forth goals, prepare plans to meet those goals, and to assess and measure progress and accomplishments on a regular and systematic basis.

GPRA poses a particular challenge for those agencies that must assess the scientific research programs they fund. In fact, the General Accounting Office (GAO) has found that measuring the discrete contribution of a federal initiative to a specific program result is particularly challenging for regulatory programs; scientific research programs; and programs that deliver services to taxpayers through third parties, such as state and local governments (U.S. GAO 1997a). Regarding research programs, GAO points out that the amount of money spent on R&D has been used as the primary indicator of how much research is being performed in a given area, but that such an *input* indicator does not provide a good indication of the *outcomes* (results) of the research. In a recent report, GAO notes that:

> ...experts in research measurement have tried for years to develop indicators that would provide a measure of the results of R&D. However, the very nature of the innovative process makes measuring the performance of science-related projects difficult. For example, a wide range of factors determine if and when a particular R&D project will result in commercial or other benefits. It can also take many years for a research project to achieve results...Experiences from pilot efforts made under the Government Performance and Results Act have reinforced the finding that output measures are highly specific to the management and mission of each federal agency and that no single indicator exists to measure the results of the research (U.S. GAO 1997b).

The Subcommittee on Research of the Committee on Fundamental Science, which operates within the President's Office of Science and Technology Policy, has been working with federal research agencies to establish a broad framework for GPRA implementation in the assessment of fundamental science programs. The subcommittee states that:

> The central issue in assessing fundamental science lies in defining the goal against which progress is measured. The Administration's science policy statement, "Science in the National Interest" [Clinton and Gore 1994], establishes that goal as leadership across the frontiers of scientific knowledge. This is the critical measure for assuring that American scientists are expanding the knowledge base at the leading edge...
>
> Leadership evaluation does not entail simplistic numerical ranking of national programs. Our national interest in leadership rests in having our research and educational programs perform at the cutting edge—sometimes in competition, but often in explicit collaboration, with scientists from other nations. This goal is the principal guideline for government stewardship of science in the national interest. It is an enabling or intermediate objective with respect to the over-arching goals of improved health and environment, national security, economic prosperity, and quality of life . . . Science drives progress toward the over-arching national goals over a long time period and only as part of a larger enterprise requiring a complex interplay of science and technological innovation with fiscal, regulatory, intellectual property rights, and trade policies. Consequently, the enabling goal of maintaining broad scientific leadership is that which guides the management and assessment of today's science investments. It provides the principal yardstick for GPRA assessment strategies for fundamental science programs (NSTC 1996).

The subcommittee concludes that retrospective evaluation will have to be the main assessment tool and that it will have to be updated periodically to examine the link between fundamental science and the overarching national goals. A final concern related to GPRA's implementation in an R&D environment is that it may cause science agencies to focus on processes and process issues and to set inflexible process goals. Such an approach is likely to interfere with the conduct of research, which must be flexible and changeable to be effective.

Agencies are still struggling with GPRA's requirements in this arena, puzzling over how to balance the need for planning with the need for flexibility; the need for short-term measures with the reality of accomplishments that will only be realized in the long term. Despite these challenges, GPRA is an important requirement and can be an opportunity for government agencies, Congress, and the university community to better communicate to the public the value of investments in R&D and education.

constant—with state and local governments providing the largest share of support, followed by institutional funds—the proportions of funding for which they account have changed, sometimes dramatically. Most strikingly, the proportion of funds provided through private donations has declined. In 1986-87, this source accounted for about 20 percent of construction and repair/renovation funding; by 1994-95, however, its share had declined to about 12 percent. This reflects a drop in private donations to public institutions. Also of note, other debt grew from a 0.2 percent share in 1986-87 to account for 5.9 percent of funds in 1994-95; this reflects the increased importance of this funding source to private institutions. During the period, funds from federal sources[19] and from tax-exempt bonds first grew in significance—the former increasing from 6 percent in 1986-87 to about 14 percent in both 1990-91 and 1992-93, and the latter from just below 16 percent to about 21 percent in 1990-91—and then dropped to account for smaller overall shares in 1994-95 (about 8 and 13 percent, respectively). (See appendix table 5-14.)

In general, the major sources of funds for new construction are not the same as those for repair/renovation. About 43 percent of the funds for new construction come from state and local governments, with about 16 percent from institutional funds. The significance of these funding sources is reversed for repair/renovation. About 41 percent of the funds for repair/renovation come from institutional funds, and 25 percent from state and local funds. The proportion of repair/renovation funds from the Federal Government increased from 6 percent in 1988-89 to slightly above 10 percent in 1994-95, while the federal proportion for new construction decreased from 14 to 8 percent during the same period. (See appendix table 5-14.)

Public and private institutions draw upon substantially different sources to fund the construction and repair/renovation of research space. (See figure 5-7.) Public institutions rely primarily on:

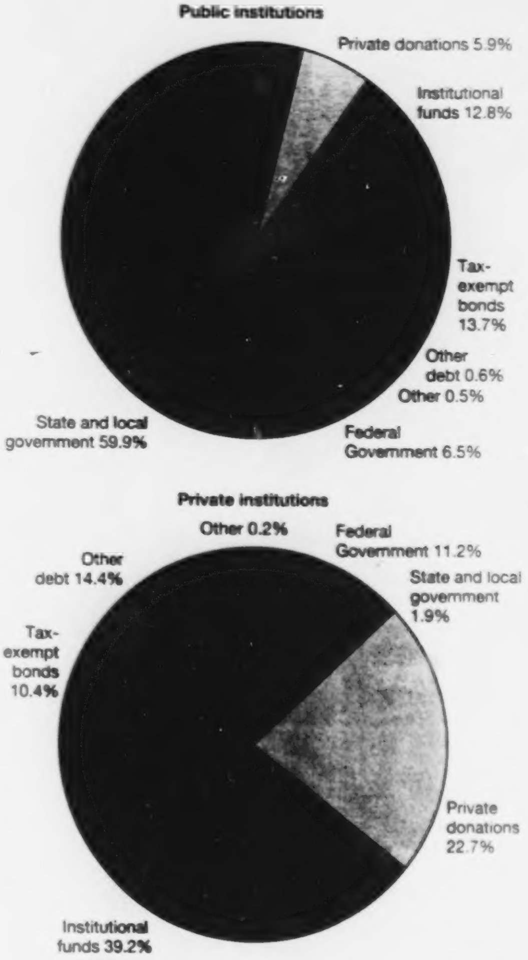
- state and local funding, which accounted for 46 percent of their total funding in 1992-93 and 60 percent in 1994-95;
- tax-exempt bonds, which accounted for 18 percent of their total funding in 1992-93 and 14 percent in 1994-95; and
- institutional funds, which accounted for 14 percent of their total funding in 1992-93 and 13 percent in 1994-95.

The Federal Government share declined from just above 14 percent in 1992-93 to below 7 percent in 1994-95.

Private institutions, for their part, rely primarily on:

- institutional funds, which accounted for 32 percent of their total funding in 1992-93 and 39 percent in 1994-95; and
- private donations, which accounted for about 18 percent of their total funding in 1992-93 and 23 percent in 1994-95.

Figure 5-7.
Funding sources for new construction and repair/renovation of S&E research space, by type of institution: 1994-95



See appendix table 5-14.

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A significant shift in the importance of tax-exempt bonds as a funding source for private institutions occurred between 1992-93—when they accounted for about 23 percent of total funding—and 1994-95, when they dropped to only about 10 percent. The decline in the importance of tax-exempt bonds over this period was roughly offset by an increase in the share of other debt from about 4 percent to about 14 percent. (See appendix table 5-14.)

Condition and Adequacy. Reported data suggest little change in the condition of academic S&E research space be-

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[19] The actual amount of federal funds devoted to construction and repair/renovation is likely to be underrepresented because substantial federal funding for this purpose is received as overhead on federal grants and contracts. These funds are counted as institutional funds and may be used for construction and repair/renovation of research facilities.

Text table 5-2.

Condition of academic science and engineering research facilities

(Percentages)

Assessed condition of academic institutions' research space	1988	1990	1992	1994	1996[a]
Suitable for use in most scientifically sophisticated research	23.9	25.9	26.8	26.4	37.2
Effective for most uses, but not most scientifically sophisticated	36.8	35.3	34.7	32.8	
Requires limited repair/renovation to be used effectively	23.5	23.3	22.6	23.1	43.9
Requires major repair/renovation to be used effectively[b]	15.8	15.5	12.8	12.9	18.5
Requires replacement[c]	NA	NA	3.1	4.1	

NA = not available

NOTE: Percentages may not total 100 because of rounding.

[a] In 1996, the survey response categories were changed to: "suitable for the most scientifically competitive research"; "effective for most levels of research, but may need limited repair/renovation"; and "requires major renovation or replacement to be used effectively."

[b] The data for 1988 and 1990 in this category include space requiring replacement.

[c] This category was first used in the 1992 survey.

See appendix table 5-15.

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tween 1988 and 1994.[20] (See text table 5-2.) Specifically, about a quarter of this space was rated as suitable for use in the most scientifically sophisticated research; about a third was judged to be effective for most uses, but not most scientifically sophisticated; less than a quarter was reported as needing limited repair/renovation; and about a sixth was said to require major repair/renovation or replacement.

The 1996 survey responses cannot be readily compared to these earlier results because the wording and response choices have been changed. Specifically, the number of response categories has been reduced from five to three: suitable for the most scientifically competitive research; effective for most levels of research, but may need limited repair/renovation; and requires major renovation or replacement to be used effectively. This change essentially resulted in a shifting of about one-third of the space characterized in 1994 as "effective for most uses, but not most scientifically sophisticated," to the new category "suitable for the most scientifically competitive research"; and the other two-thirds to the new category "effective for most levels of research, but may need limited repair/renovation."

Unmet Needs. Determining what universities and colleges need with regard to S&E research space is a complex matter. In order to measure real as opposed to speculative needs, the 1994 facilities survey adopted a new approach to this issue. Faculty respondents were asked to report whether an approved institutional plan existed that included any deferred space needing new construction or repair/renovation.[21] Respondents were then asked to estimate, for each S&E field, the costs of such construction and repair/renovation projects. The 1996 survey expanded on this question by asking institutions to report separately the construction and repair/renovation costs for projects included in such plans, as well as for projects not included.

In 1994, a total of 40 percent of all research-performing universities and colleges had an approved institutional plan that included construction or repair/renovation projects that were either deferred and unfunded.[22] The estimated cost of these projects in constant dollars was $6.2 billion: $4.4 billion for new construction and $1.8 billion for repair/renovation. In 1996, 44 percent of research-performing institutions reported having an approved institutional plan that included construction or repair/renovation projects that were needed but that had to be deferred because funds were not available. These plans cited $7.4 billion of deferred capital project expenditures in constant dollars—$4.6 billion for new construction and $2.8 billion for repair/renovation. This total represents a $1.2 billion increase in deferred capital project costs between 1994 and 1996, the majority for repair/renovation ($970 million) and the remainder in deferred construction costs ($259 million). Another 11 percent of research-performing institutions identified $1.9 billion of needed deferred capital project expenditures that were not included in an institutional plan—$1.0 billion for new construction and $0.9 billion for repair/renovation.

Facilities by S&E Field

There was little change in the distribution of academic research space across S&E fields between 1988 and 1996. (See appendix table 5-12.) About 90 percent of current academic research space continues to be concentrated in six fields:

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[20] Since the Survey of Scientific and Engineering Research Facilities at Universities and Colleges from which the results are derived is a sample survey, the small changes reported are not likely to be statistically significant.

[21] Four criteria were used to define deferred space in the 1994-95 survey: (1) the space must be necessary to meet the critical needs of current faculty or programs, (2) construction must not have been scheduled to begin during fiscal years 1994-95, (3) construction must not have funding set aside for it, and (4) the space must not be for developing new programs or expanding the number of faculty.

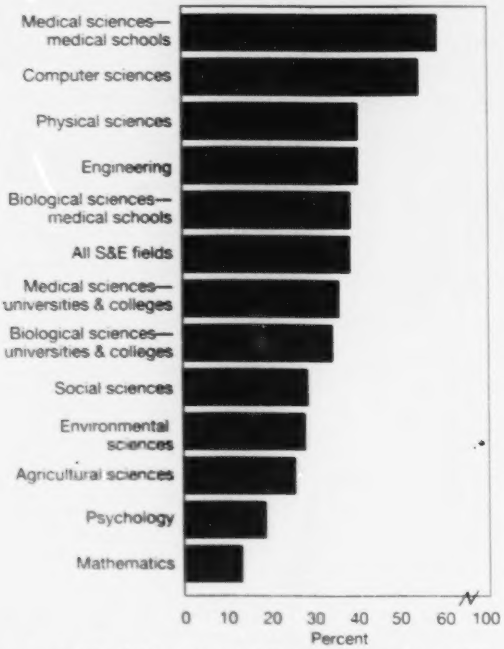
[22] The other 60 percent of the institutions surveyed might have needed new construction or repair/renovation but didn't have an approved institutional plan to that effect. Certain classes of institutions (smaller institutions, historically black colleges or universities) were less likely to have either a plan or a plan that includes deferred needs. Of those surveyed, the top 100 institutions in terms of research expenditures were most likely to have an approved institutional plan (60 percent), and the nondoctorate-granting institutions were least likely (26 percent).

- the biological sciences (21 percent in 1988 and 22 percent in 1996),
- the medical sciences (17 percent in 1988 and 18 percent in 1996),
- engineering (from 14 to 16 percent),
- the agricultural sciences (16 percent in both years),
- the physical sciences (from 14 to 13 percent), and
- the environmental sciences (from 6 to 5 percent).

The ratio of planned new construction during the 1986-95 period to existing research space differs across S&E fields.[23] More than half of the research space for medical sciences at medical schools and for computer sciences appears to have been built in the 1986-95 period. In contrast, less than 20 percent of the research space for mathematics and psychology appears to have been newly constructed during this period. (See figure 5-8.)

Condition and Adequacy. The condition of academic research space also differs across S&E fields. In 1996, the agricultural sciences reported the largest proportion among all S&E fields—about 24 percent—of research space in need of major repair/renovation or replacement. Other fields with higher than average needs for repair/renovation or replacement are the physical sciences (19 percent of total research space), the environmental sciences (19 percent), and the medical sciences both in universities and colleges (21 percent) and in medical schools (20 percent). In contrast, major repair/renovation or replacement was needed for only 13 percent of the total research space in the social sciences, 12 percent in psychology, 10 percent in mathematics, and less than 8 percent in the computer sciences. No particular trends have emerged as yet with respect to changes over time in repair/renovation needs across S&E fields. (See appendix table 5-15.)

Figure 5-8.
Percentage of S&E research space newly constructed between 1986 and 1995, by field: 1996



See appendix table 5-12.   *Science & Engineering Indicators – 1998*

In 1994, 40 percent or more of all institutions surveyed indicated inadequate amounts of research space in engineering, the physical sciences, the biological sciences outside of medical schools, and the medical sciences in medical schools. (See appendix table 5-16.) One-third or less of all institutions surveyed indicated inadequate amounts of S&E research space in the environmental sciences, the agricultural sciences, mathematics, psychology, and the social sciences. In 1996, 40 percent or more of all institutions indicated inadequate amounts of research space in all S&E fields except mathematics. More than half of all institutions indicated inadequate amounts of research space in engineering, the physical sciences, the biological sciences outside of medical schools, the medical sciences (both in and outside of medical schools), and the agricultural sciences. It is unclear how much of the change that occurred over the two periods is due to changes in the survey questionnaire rather than to an increasing inadequacy of research space.[24]

Unmet Needs. Deferred and unfunded needs existed in all S&E fields in 1996. The fields most frequently cited as having an unfunded need for new construction of research facilities as part of an institutional plan were the agricultural sciences (21 percent), engineering (19 percent), the medical sciences in medical schools (14 percent), and the physical sciences (13 percent). (See text table 5-3.) Unfunded need for repair/renovation projects reported in an institutional plan was indicated most strongly in the biological and medical sciences within medical schools (31 and 30 percent, respectively). An additional set of institutions reported deferred capital projects for both new construction and repair/renovation without an institutional plan in all S&E fields, with a larger percentage of institutions in each field reporting a need for repair/renovation projects than for new construction projects.

In four fields, estimated expenditures for needed capital projects (new construction plus repair/renovation) were over $1 billion (including those identified in an institutional plan or not in a plan): the physical sciences ($1.9 billion), engineering ($1.5 billion), the biological sciences outside of medical schools ($1.4 billion), and the medical sciences in medical schools ($1.3 billion). (See appendix table 5-17.)

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[23] As noted earlier, the actual percentage of existing space that may have been repaired/renovated is not known because some space may have been repaired/renovated more than once.

[24] Again, the response choices were changed in 1996 compared to previous survey years. In 1994 and earlier, respondents were asked to rate the amount of research space in each field as either adequate, generally adequate, inadequate, nonexistent but needed, or not applicable or not needed. In 1996, these choices were narrowed down to three: adequate; inadequate, including insufficient; or not applicable or not needed.

Text table 5-3.

Percentage of institutions with deferred capital projects to construct and/or repair/renovate S&E research facilities, by field, with and without an institutional plan: 1996

Field	Percentage of institutions[a]			
	With plan		Without plan	
	Construction	Repair/renovation	Construction	Repair/renovation
Physical sciences	13	22	3	12
Mathematics	2	10	3	6
Computer sciences	2	8	6	6
Environmental sciences	5	18	4	5
Agricultural sciences	22	19	11	14
Biological sciences				
Universities & colleges	10	17	5	14
Medical schools	10	32	3	10
Medical sciences				
Universities & colleges	10	13	6	12
Medical schools	14	30	3	12
Psychology	2	7	3	7
Social sciences	3	7	4	10
Engineering	21	26	4	9

[a] Percentage of all responding institutions with research space in the relevant S&E field.

SOURCE: National Science Foundation, Science Resources Studies Division, *Scientific and Engineering Research Facilities at Universities and Colleges: 1996*, NSF 96-326 (Arlington, VA: 1996).

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Instrumentation

Expenditures.[25] In 1995, just over $1.2 billion in current fund expenditures was spent for academic research instrumentation. Over 80 percent of these expenditures were concentrated in three fields: the life sciences (38 percent), engineering (23 percent), and the physical sciences (19 percent). (See figure 5-9.)

Between 1985 and 1995, current fund expenditures for academic research instrumentation first increased—growing at an average annual rate of 6.5 percent between 1985 and 1989—then dipped—dropping about 2 percent a year for the next four years—before recovering and growing by 3.6 percent from 1993 to 1994 and by 9.6 percent from 1994 to 1995 (in constant 1992 dollars). There were variations in growth patterns during this period among S&E fields. (See appendix table 5-18.)

Federal Funding. Federal funds for instrumentation are generally received either as part of research grants—thus enabling the research to be performed—or as separate instrumentation grants, depending on the funding policies of the particular federal agencies involved. The importance of federal funding for research instrumentation varies by field. In 1995, the social sciences received about 40 percent of their research equipment funds from the Federal Government. In contrast, federal support accounted for over 60 percent of instrumentation funding in the physical sciences, computer sciences, environmental sciences, psychology, and engineering.

Since 1985, the share of research instrumentation expenditures funded by the Federal Government has declined—although not steadily—dropping from 64 to 59 percent. This overall pattern masks different trends in individual S&E fields. In one field—the environmental sciences—federal support actually rose, albeit very slightly, accounting for just below 68 percent of the field's instrumentation support in 1985 and just above 68 percent in 1995. Two other fields experienced sharp declines in federal support during this decade. The federal share for mathematics instrumentation dropped from 82 to 59 percent, and the share for computer sciences instrumentation dropped from 83 to 62 percent.

R&D Equipment Intensity. R&D equipment intensity is the percentage of total annual R&D expenditures from current funds devoted to research equipment. This proportion has declined since 1986, when research equipment accounted for 7.2 percent of total R&D expenditures. (See appendix table 5-19.) By 1993, R&D equipment intensity had dropped to 5.2 percent; it has since increased—slightly—to 5.6 percent in 1995.

R&D equipment intensity varies across S&E fields. It tends to be higher in the computer sciences (11.3 percent in 1995), physical sciences (10.6 percent), and engineering (8.2 percent); and lower in the social sciences (2.6 percent), psychology (3.3 percent), and life sciences (3.8 percent). This disparity is probably the result of the latter three fields using less equipment and/or less expensive

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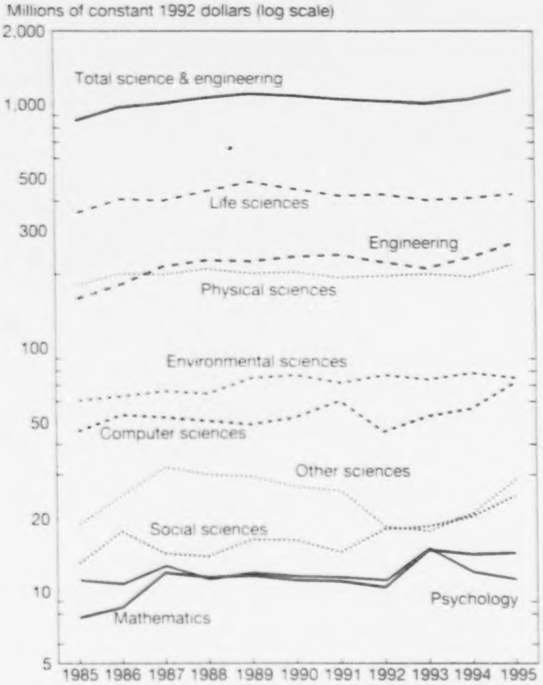
[25] Data used here are from the NSF Survey of Scientific and Engineering Expenditures at Universities and Colleges; they are limited to current funds expenditures for research instrumentation and do not include funds for instructional equipment. Current funds—as opposed to capital funds—are those in the yearly operating budget for ongoing activities. Generally, academic institutions keep separate accounts for current and capital funds.

Figure 5-9.
Current fund expenditures for research equipment at academic institutions, by field



NOTE: See appendix table 4-1 for GDP implicit price deflators used to convert current dollars to constant 1992 dollars.

See appendix table 5-18. *Science & Engineering Indicators – 1998*

instruments than the former three. Although the recent steady decline in R&D equipment intensity was not felt equally in all S&E fields, the 1986 figure was higher than that for 1995 in every field except mathematics. In that field, research equipment as a proportion of total R&D expenditures rose from 4.5 percent in 1986 to 5.4 percent in 1995. The data indicate, however, that the decline in R&D equipment intensity began to level off or reverse in 1993 for most S&E fields.

Stock, Condition, and Use. By congressional mandate, NSF has monitored academic research instrumentation status and needs since the early 1980s.[26] As of 1993 (the most recent year for which detailed instrumentation data are available), the 318 colleges, universities, and medical schools represented in the survey reported a combined estimated stock of 61,684 instruments, with an estimated aggregate original purchase price of $6.255 billion.[27] These instruments are categorized as shown in text table 5-4; their condition and usage were rated as follows:

- **Maintenance and repair.** Respondents rated 64 percent of the instruments as receiving above adequate to excellent maintenance/repair in 1993. Maintenance/repair was judged less than adequate or poor for only 8 percent of all instruments.

- **State-of-the-art status.** Overall, 27 percent of the instruments in research usage were rated as state of the art. An additional 63 percent were not state of the art, but were considered adequate for user needs. Only 9 percent were rated as inadequate.

- **Average age.** About 40 percent of the research instruments in use in 1993 had been acquired within the previous four years. Another 23 percent were over eight years old, and the average age of a research instrument was 5.8 years. (See appendix table 5-22.) Seventeen percent of all instruments costing under $1 million were less than two years old in 1993, but only 7 percent of instruments over $1 million were that new.

- **Use.** Sixty-four percent of the instruments reported in research use in 1993 were used exclusively for research. Most of the remainder (32 percent) were used predominantly for research with some instructional use. Only 4 percent of the total were used primarily for instruction with some research use.

- **Average number of users.** An average of 24.2 users per instrument was reported. Graduate students and postdoctorates assigned to the unit owning the instrument (i.e., the host unit) comprised the single largest category of user—an average of 8.5 per instrument. On average, there were also 3.5 faculty users from the host unit, 6.0 researchers from other units in the host institution, 4.5 researchers from outside the host institution, and 1.8 other users (primarily staff and undergraduates). In general—and not surprisingly—the higher an instrument's state-of-the-art ranking, the greater the number of researchers using it. For instance, an average of 25.7 researchers used the state-of-the-art instruments, while an average of 24.2 used the instruments that were not state of the art but that were adequate for their research. An average of 20.5 researchers worked with instruments that were rated as inadequate.

Needs. In the 1994 Instrumentation Survey, most (69 percent) of the responding heads of academic departments and research facilities reported that their research instrumentation needs had increased since the last survey in 1992. A slim majority—58 percent—were satisfied with the overall capability of their existing instrumentation to support their faculty's research interests. The remaining 42 percent rated their

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[26] These data are collected via NSF's National Survey of Academic Research Instruments and Instrumentation Needs (Instrumentation Survey). NIH also provides funding for this survey. The survey consists of (1) questionnaires (now distributed every other year) that collect data on departmental equipment expenditures, equipment needs, and priorities; and (2) instrument data sheets (now distributed every four years) that collect detailed data from principal investigators on the condition, cost, usage, etc., of specific research instruments.

[27] For a more complete discussion of the characteristics of academic R&D instrumentation by S&E field, see NSF (1997b and 1998c).

Text table 5-4.
Research instrument stock, by category: 1993

Instrument category	Number	Cost (billion $)	Percentage of Total stock	Percentage of Total cost
Computers and data handling	12,023	1.85	19	30
Chromatographs and spectrometers	13,789	1.29	22	21
Microscopy	5,597	0.55	9	9
Bioanalytical	10,205	0.47	17	7
Other	20,071	2.10	33	34
Electronics and lasers	6,958	0.43	11	7
Major instrument systems[a]	1,295	0.64	6	10

NOTE: Cost reflects original purchase price.

[a] Major instrument systems include research vessels, telescopes, and other major instruments such as nuclear reactors, wind/wave/water/shock tunnels, and major prototype systems. See appendix table 5-22 for a complete breakdown.

SOURCE: National Science Foundation, Science Resources Studies Division, "Total Stock of Academic Research Instruments Tops $6 Billion in 1993," Data Brief, NSF 97-309 (Arlington, VA: 1997).

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research instrumentation as inadequate, and estimated the cost of the requisite upgrading at a total of $1.438 billion.

All respondents were asked to list and estimate the combined cost of the three top-priority research instruments costing over $20,000 their faculty most needed. Ten percent of the respondents said they had no immediate needs for additional instruments in this price range. For the others, the total combined cost of these items would be $2.048 billion, of which $942 million would be required for the top-priority item only. The primary reason cited for these top-priority research instruments was to upgrade unit capabilities—i.e., to perform experiments that the unit "cannot do now." The share from departments that reported inadequate overall instrumentation is an estimated cost of $939 million for their top three priority items—or about 65 percent of the $1.438 billion estimated cost to "fix" their units' overall instrumentation needs.[28]

Academic Doctoral Scientists and Engineers

This section examines major trends over the 1973-95 time period regarding the composition of the academic S&E workforce, its primary activities (teaching vis-à-vis research), and the extent of its support by the Federal Government. For a discussion of the nature of the data used here, see "Data Sources: Nature, Problems, and Comparability."

The Academic Doctoral S&E Workforce[29]

The total number of scientists and engineers in the U.S. labor force with doctoral degrees from U.S. universities has more than doubled over the past two decades, rising from about 215,000 in 1973 to 475,200 in 1995; the academic component increased from an estimated 118,000 to 217,500.[30] (See text table 5-5.) The rate of academic employment growth, though robust over much of the period, was lower than growth in other sectors. The growth rate for academic employment dropped from nearly 7 percent annually in the early 1970s to just under 1 percent from 1989 onward; consequently, the academic employment share declined from an estimated 55 percent in 1973 to 46 percent in the 1990s.

While the total number of academic doctoral scientists and engineers continued to rise from 206,700 in 1989 to 217,500 in 1995, the number of incumbents holding full-time faculty positions—full, associate, and assistant professors plus instructors—remained roughly stable at between 169,800 and 173,100. (See figure 5-10.) Consequently, the share of full-time faculty among all academic doctoral scientists and engineers declined to an all-time low of 79 percent. This drop continued a downtrend evident since the early

Text table 5-5.
Academic employment of doctoral scientists and engineers: Number, growth rate, and employment share

	Employment (thousands)		Average annual rate of change		Academic share of employment
	Total	Academia	Total	Academia	
1973	215.0	118.0			55
1975	250.8	134.1	8.02	6.60	53
1977	277.2	145.5	5.12	4.15	52
1979	306.7	155.4	5.19	3.35	51
1981	336.1	167.1	4.69	3.72	50
1983	363.1	176.2	3.93	2.68	49
1985	395.7	190.3	4.39	3.93	48
1987	416.5	196.0	2.60	1.48	47
1989	447.3	206.7	3.63	2.70	46
1991	468.6	210.6	2.36	0.92	45
1993	460.5	213.8	–0.87	0.75	46
1995	475.2	217.5	1.58	0.88	46

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Doctorate Recipients, unpublished tabulations.

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[28] For a more complete discussion of academic instrumentation needs by S&E field and by major instrument category and field, see NSF (1996a).

[29] The academic doctoral S&E workforce includes full, associate, and assistant professors and instructors—collectively defined throughout this section as faculty—lecturers, adjunct faculty, research and teaching associates, administrators, and postdoctorates.

[30] The trend data in this section refer to scientists and engineers with doctorates from U.S. institutions, regardless of their citizenship status. Comparable trend data for Ph.D.-level scientists and engineers with degrees from non-U.S. institutions are not available. A 1993 U.S. Department of Education survey of academic faculty suggests that this component of the academic workforce numbers around 13,000.

Data Sources: Nature, Problems, and Comparability

The data used in this section to describe the employment, characteristics, and activities of academic doctoral scientists and engineers derive mainly from the Survey of Doctorate Recipients (SDR) and in part from the National Study of Postsecondary Faculty (NSOPF).

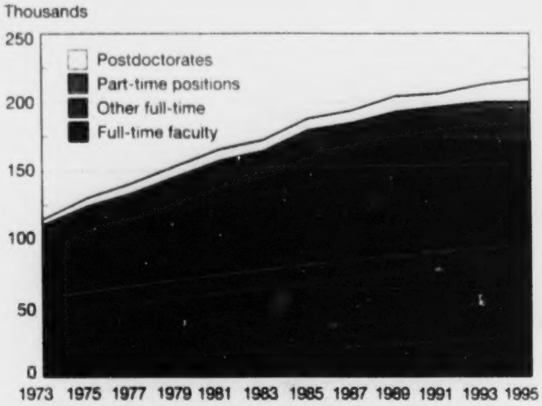
SDR is a sample survey conducted biennially since 1973 under the sponsorship of the National Science Foundation and several other federal agencies. The survey underwent several changes in 1991, and again from 1993 forward; these affect the comparability of data from these years with those of earlier periods. Through 1989, the sample included three major respondent segments: (1) recipients of S&E doctorates from U.S. institutions; (2) a small number of doctorate-holders in other fields who were working in S&E in the survey year; and (3) a small number of people with S&E doctorates from non-U.S. institutions.

Starting with the 1991 sample, only recipients of S&E doctorates from U.S. universities were retained, and persons over 75 years old were ruled out of scope. Further, sampling strata and sample size were reduced in an effort to improve response rates within budget constraints. Other changes in data collection also were introduced, most notably the use of computer-assisted telephone interviewing, which resulted in much higher response rates than had been attained previously. A 31-month interval elapsed between the 1989 and 1991 surveys instead of the usual 24 months; the interval between the 1991 and 1993 surveys was 20 months.

Methodological studies to assess the full impact of these changes on overall estimates and individual data items remain to be conducted. Preliminary investigations suggest that SDR data permit analysis of rough trends, provided comparisons are limited to recipients of S&E doctorates from U.S. institutions. This has been done herein, with data structured in accordance with suggestions offered by the National Research Council's Office of Scientific and Engineering Personnel, which has conducted all of these surveys through 1995. Nevertheless, in the text and tables presented here, apparently interesting but small statistical differences should be treated with caution.

NSOPF is a sample survey that was conducted by the U.S. Department of Education in 1988 and 1993. The two NSOPF survey frames are not comparable. Those with no teaching duties in the fall semester of 1988 were considered out of scope, while the comparable group was included in the 1993 cycle. Internally consistent subsets can be constructed and compared across the two survey years, however. Because the NSOPF estimates of doctoral scientists and engineers agree quite well with those derived from SDR, and since NSOPF contains information on teaching activities that is unavailable from SDR, data from this survey have been used to supplement SDR information.

Figure 5-10.
Academic doctoral scientists and engineers, by type of position



NOTE: Faculty positions include full, associate, and assistant professor and instructor.

See appendix table 5-23. *Science & Engineering Indicators – 1998*

1970s, when this share had stood at 88 percent. Psychology and the physical, environmental, and life sciences experienced particularly substantial shifts toward nonfaculty employment, with full-time faculty percentages dropping by 10 or more points. Developments in the social sciences, mathematics, and engineering were somewhat less pronounced. (See appendix table 5-23.)

The number of incumbents in other types of academic positions—full- and part-time adjunct faculty, lecturer, research and teaching associate, administrator, postdoctorate—grew at a more rapid rate than the number of full-time faculty, increasing from 14,700 in 1973 to 46,200 in 1995. The 1989-95 increase was 25 percent, in contrast to the essentially flat full-time faculty count. Most of the growth in this segment was due to postdoctorate[31] and other full-time appointments; part-time employees accounted for between 2 and 3 percent of the total throughout. (See appendix table 5-23.)

Employment growth was not uniform across different segments of higher education. Universities categorized as research universities in the Carnegie classification system experienced slower growth than other institutions;[32] their doctoral S&E staff increased by 56 percent, from 57,600 in 1973 to 90,100 in 1995. Other universities and colleges combined had twice that rate of increase, as their numbers went from 60,400 in 1973 to 127,400 in 1995. Consequently, the proportion of academic doctoral scientists and engineers employed by research universities dropped from 49 to 41 percent during the period. (See text table 5-6.)

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[31] For more information on this subject, see "Postdoctoral Appointments" in chapters 2 and 3.

Women in the Academic Doctoral S&E Workforce[33]

The number of academically employed women with S&E doctorates rose more than fourfold between 1973 and 1995, increasing from about 10,700 to an estimated 52,400. In comparison, the number of men increased by roughly 54 percent over the period, from 107,300 to 165,100. Consequently, men's employment share dropped by 15 percentage points, from 91 percent in 1973 to 76 percent in 1995. Women's gains were especially pronounced in psychology and the life and social sciences, fields where their participation in 1973 had already been the highest. (See appendix table 5-24.)

The recent decline in the full-time faculty component, discussed above, was driven by an estimated 10 percent drop in the number of male full professors since 1989—from 76,300 to 68,800—combined with roughly stable numbers of male associate professors and junior faculty (assistant professors and instructors). (See figure 5-11.) But the number of women serving as full professors, associate professors, and junior faculty—assistant professors and instructors—increased by 30 percent or more during this time. By 1995, women constituted 21 percent of full-time S&E faculty. The number of women also increased faster than the number of men—41 versus 17 percent since 1989—in the other types of academic positions: full- and part-time adjunct faculty, lecturer, research and teaching associate, administrative, and postdoctorate. (See appendix table 5-24.)

Throughout the period, the field distribution of women remained more concentrated than that of men. Fully 84 percent of women scientists and engineers in 1995 were found in three broad fields: life sciences (41 percent), social sciences (21 percent), and psychology (22 percent). In contrast, only 58 percent of men were in these fields in 1995. Conversely, only 8 percent of women, but 19 percent of men, were in the physical and environmental sciences; and just 3 percent of women were in engineering versus 14 percent of men. (See appendix table 5-24.)

These field distributions in academic employment reflect the different field patterns of doctorate degrees earned by men and women. Over the past two decades, increased hiring of women into academia has been commensurate with women's rising proportion of new S&E doctorates. Among

Text table 5-6.
Academic doctoral scientists and engineers, by type of employing institution

	Thousands employed by:			Percentage employed by:	
	Academia (total)	Research universities	All other institutions	Research universities	All other institutions
1973 ...	118.0	57.6	60.4	49	51
1975 ...	134.1	63.3	70.8	47	53
1977 ...	145.5	67.7	77.8	47	53
1979 ...	155.4	71.3	84.1	46	54
1981 ...	167.1	78.5	88.6	47	53
1983 ...	176.2	77.2	99.1	44	56
1985 ...	190.3	85.5	104.8	45	55
1987 ...	196.0	91.3	104.7	47	53
1989 ...	206.7	93.8	112.9	45	55
1991 ...	210.6	93.5	117.1	44	56
1993 ...	213.8	92.8	120.9	43	57
1995 ...	217.5	90.1	127.4	41	59

NOTE: Institution types are based on the Carnegie Foundation for the Advancement of Teaching classification of higher education institutions.

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Doctorate Recipients, unpublished tabulations.

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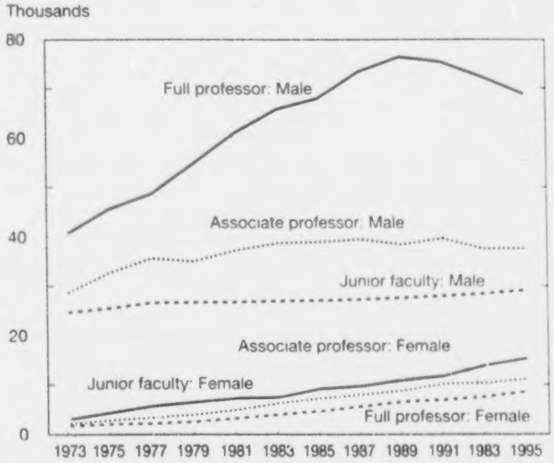
Figure 5-11.
Full-time doctoral S&E faculty, by rank and sex



NOTE: Faculty positions include full, associate, and assistant professors plus instructors. Junior faculty members are either assistant professors or instructors.

SOURCE: National Science Foundation, Survey of Doctorate Recipients, unpublished tabulations.

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recent Ph.D.s in academic employment,[34] women have been represented in rough proportion to their share of newly awarded doctorates in every major field over the entire 1973-95 period. However, their proportion of the doctoral academic S&E workforce—24 percent in 1995—continues to lag their percentage of new S&E doctorates—38 percent. (See text table 5-7.)

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[32] This periodically revised classification describes research universities as institutions with a full range of baccalaureate programs, commitment to graduate education through the doctorate, annual award of at least 50 doctoral degrees, and receipt of federal support of at least $15.5 million (average of 1989 to 1991). See Carnegie Foundation for the Advancement of Teaching (1994).

[33] Also see chapter 3, "Women in the S&E Workforce."

Underrepresented Minorities in the Academic Doctoral S&E Workforce[35]

Academic employment of underrepresented minorities—blacks, Hispanics, Native Americans, and Alaskan Natives[36]—rose to 12,800 in 1995 from 2,400 in 1973. Their employment share rose from 2 percent in 1973 to 6 percent in 1995, the same as their share of full-time faculty positions. Relative gains for underrepresented minorities were greatest in psychology and the social sciences—where their employment share rose from 2 to 8 percent—and in engineering—from 2 to 5 percent. (See appendix table 5-25.)

These low but rising numbers reflect the growing number of S&E Ph.D.s earned by members of underrepresented minorities.[37] For the past two decades, underrepresented minorities have been hired into academic positions at somewhat higher rates than would be expected based on their share of new S&E Ph.D.s awarded. As a consequence, their representation in the total academic workforce has been close to their share of new doctorates. (See text table 5-7.)

The distribution of underrepresented minorities by field is similar to that of whites, with two exceptions. Underrepresented minorities are *less* likely than whites to be in the life sciences—28 versus 34 percent, and they are *more* likely to be in psychology and the social sciences—41 versus 33 percent.

Asians in the Academic Doctoral S&E Workforce[38]

Asians as a group have been quite successful in entering the academic workforce. The number of Asian academic doctoral scientists and engineers rose rapidly between 1973 and 1995, increasing from 5,100 to 22,500 in 1995. This growth more than doubled their employment share: 10 percent in 1995 versus 4 percent in 1973. Asians made especially strong gains in the physical sciences (from 5 percent in 1973 to 14 percent in 1995), computer sciences (from 13 percent in 1985 to 29 percent in 1995),[39] and engineering

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[34] Recent Ph.D.s are those who have earned their doctorates within the past three years.

[35] Also see chapter 3, "Racial/Ethnic Minorities in the S&E Workforce."

[36] There is variation among and within these groups, which are treated here in the aggregate. Appendix table 5-25 provides somewhat more detailed data; the survey sample does not permit further disaggregation. Asians as a group have been quite successful in entering the academic workforce and are treated separately.

[37] This in turn, of course, reflects their increasing participation in higher education and graduate school training. See chapter 2, "Master's Degrees by Race/Ethnicity" and "Doctoral Degrees by Race/Ethnicity."

[38] Again, also see chapter 3, "Racial/Ethnic Minorities in the S&E Workforce."

[39] Pre-1985 estimates are unreliable because of the low number of computer science degree-holders in the sample.

Text table 5-7.
Women, underrepresented minorities, and Asians in academic doctoral S&E employment

	Recent academic S&E Ph.D.s[a] (thousands)	Women as a percentage of:			Underrepresented minorities as a percentage of:[b]			Asians as a percentage of:		
		New S&E doctorates	Recent academic S&E Ph.D.s[a]	Total academic workforce	New S&E doctorates	Recent academic S&E Ph.D.s	Total academic workforce	New S&E doctorates	Recent academic S&E Ph.D.s[a]	Total academic workforce
1973	25.0	12	12	9	2	2	2	7	5	4
1975	23.4	16	17	10	3	4	2	6	7	5
1977	22.5	19	19	11	4	5	3	5	8	5
1979	20.9	22	21	12	5	5	3	6	8	6
1981	20.7	25	25	14	5	5	4	6	8	7
1983	20.5	28	28	15	5	5	4	5	10	7
1985	21.8	31	29	16	5	5	4	6	11	7
1987	21.1	32	29	17	6	6	4	6	12	8
1989	23.3	34	31	19	6	7	4	6	14	8
1991	25.5	36	35	20	6	7	5	7	16	8
1993	25.1	37	33	22	7	7	5	8	21	10
1995	26.9	38	38	24	7	7	6	15	23	10

[a] Recent academic S&E Ph.D.s are defined as those in academic positions at the time of survey who have earned their S&E degree in the preceding three years.

[b] Underrepresented minorities in S&E include black, Hispanic, Native American, and Alaskan Native respondents.

SOURCES: National Science Foundation, Science Resources Studies Division, Survey of Earned Doctorates and Survey of Doctorate Recipients, unpublished tabulations.

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(from 9 percent in 1973 to 21 percent in 1995). (See appendix table 5-25.)

Asians are increasingly prominent among new Ph.D.s in academia, well in excess of their share of S&E Ph.D.s awarded to U.S. citizens and permanent visa-holders. That is, Asians, more than any other group, tend toward academic employment. By 1995, Asians accounted for nearly one-quarter of all new academic S&E doctorates. (See text table 5-7.)

Fifty-four percent of Asian academic S&E doctorates are in the physical, environmental, and computer sciences; mathematics; or engineering—a much higher proportion than for whites (33 percent) or underrepresented minorities (32 percent). Few Asians enter psychology, and a relatively small proportion is in the social sciences. (See appendix table 5-25.)

Employment Growth by Field

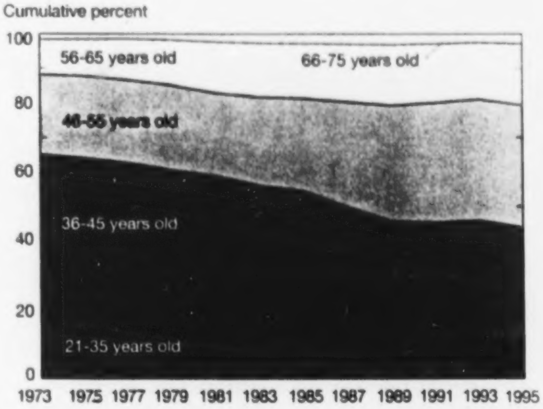
Academic employment in the physical sciences grew more slowly than in other fields over the 1973-95 period, rising from 22,100 to 29,300—33 percent growth compared to 84 percent for all of S&E combined. As a result, the share of academic doctoral scientists and engineers employed in the physical sciences fell from 19 to 13 percent; this drop was experienced in both physics and chemistry. In contrast, employment in the life sciences increased by more than 100 percent over the period, rising from 34,900 to 71,600; this field's employment share rose from 30 to 33 percent. Other fields experiencing relative gains were engineering and psychology. (See appendix tables 5-24 and 5-25.)

The Shifting Faculty Age Structure

The rapid pace of hiring of young Ph.D.s into academic faculty positions during the 1960s to accommodate soaring enrollments, combined with slower hiring in later years, resulted in an aging professoriate. (See figure 5-12.) Through the 1980s, a growing proportion of academic faculty was found in the older age brackets. A noteworthy feature of the data involves the upper end of these age distributions. The fraction of total faculty older than 65 has been about 3 percent for the past decade, with 1 percent older than 68 years. By and large, academics tend to retire before that age.

Concerns had been voiced early in the decade about the possible deleterious effects of delayed faculty retirements resulting from the full applicability of provisions of the Age Discrimination in Employment Act to universities and colleges starting in 1994.[40] The concerns focused on the potential ramifications for universities' organizational vitality, institutional flexibility, and financial health. A study by the National Research Council (NRC) concludes that "overall, only a small number of the nation's tenured faculty will continue working in their current positions past age 70" (NRC 1991, p. 29), but adds: "At some research universities a high proportion of faculty would choose to remain employed past age 70 if allowed to do so" (NRC 1991, p. 38).

Figure 5-12.
Age distribution of full-time doctoral S&E faculty



NOTE: Faculty positions include full, associate, and assistant professor and instructor.

See appendix table 5-26. *Science & Engineering Indicators – 1998*

Recent data indicate, however, that, for the system as a whole, little has changed in the last decade in terms of retirement behavior. (See appendix table 5-27.) Across all of higher education, about 3 percent of full-time faculty stay on beyond age 65. As anticipated by the NRC study, faculty at research universities tend to keep working longer than those elsewhere. But it is also worth noting that research universities have managed to maintain a relatively more balanced age structure than other types of universities and colleges. (See appendix table 5-27.) The faculty age distribution in research universities tended to be older, on average, than that of other academic institutions through the early 1980s, but that tendency has since reversed. By 1995, research universities had a greater share of their full-time faculty in the under-46 age brackets than other institutions, and a slightly greater share in the above-60 ones as well. (See figure 5-13.)

The mean and median ages of full-time doctoral faculty show a clear upward trend from 1973 through 1989, with a flattening thereafter. (See figure 5-14.) This result can now be interpreted in light of the overall number of faculty, which grew through 1989 and has since essentially held steady in the range of 169,800 and 173,100. During the years of growth, the average faculty age climbed from 42.5 to 47.1 years before leveling off. This suggests that for academia as a whole—not necessarily for individual institutions or departments—a rough balance has been maintained between attrition from all causes and new hires. However, the number of replacements from 1989 onward has to be seen in the context of Ph.D. awards which rose by more than one-fifth overall from 1989 to 1995 (up from 22,705 to 27,846) and by 30 percent for U.S.

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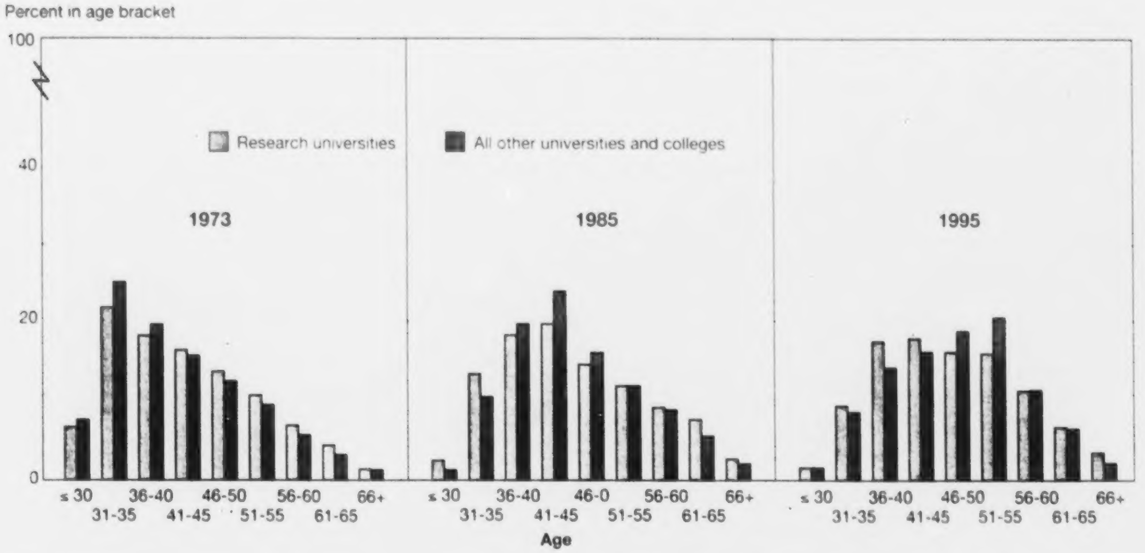
[40] A 1986 amendment to the Age Discrimination in Employment Act of 1967 prohibited mandatory retirement on the basis of age for almost all workers. Higher education institutions were granted an exemption through 1993, allowing termination of employees with unlimited tenure who had reached age 70.

Figure 5-13.
Age distribution of full-time doctoral S&E faculty at research universities and other academic institutions



NOTES: Faculty positions include full, associate, and assistant professor and instructor. Research universities are defined by 1994 Carnegie categories. See appendix table 5-27.

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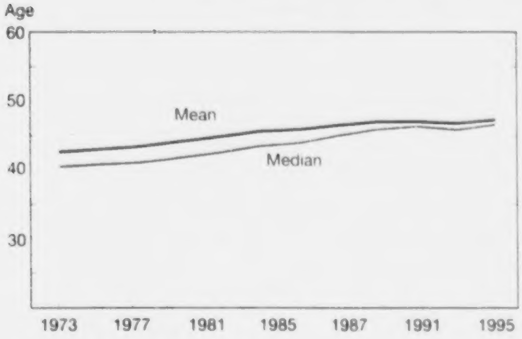
Figure 5-14.
Average age of full-time doctoral S&E faculty



NOTE: Faculty positions include full, associate, and assistant professor and instructor.

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Doctorate Recipients, unpublished tabulations.

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citizens and permanent residents. (This latter growth reflects in part Chinese students' conversion to permanent visa status following the Tiannanmen Square events.) In short, the modest increases in hiring from the late 1980s onward took place against a backdrop of steeply rising numbers of new Ph.D.s.

New Ph.D.s in Academic Employment[41]

The presence in academic employment of people with newly earned S&E doctorates provides a leading-edge indicator of the future composition of the academic teaching and research workforce. Because of the small number of new Ph.D. recipients entering academic employment relative to the size of the existing workforce, changes in the overall composition of the academic workforce will occur slowly—but are already visible, as noted above.

The number of recent Ph.D.s entering into academia—defined as those who had earned their doctorate in the three years preceding the survey—declined gradually from 25,000 in 1973 through the early 1980s, reaching a low of 20,500. It then rose again through the mid-1990s, reaching 26,900 in 1995. These represent just over half of all recent doctorate-holders. (See appendix table 5-28.) But the meaning of academic "employment" has changed for these young Ph.D.s. Fewer than 45 percent had regular faculty appointments in 1995, compared with over 75 percent in the early 1970s and 57 percent in the mid-1980s. (See figure 5-15.) Since 1973, the proportion of new doctorate recipients holding postdoctorate positions has increased steeply, rising from 13 to 28 percent in 1985 and 40

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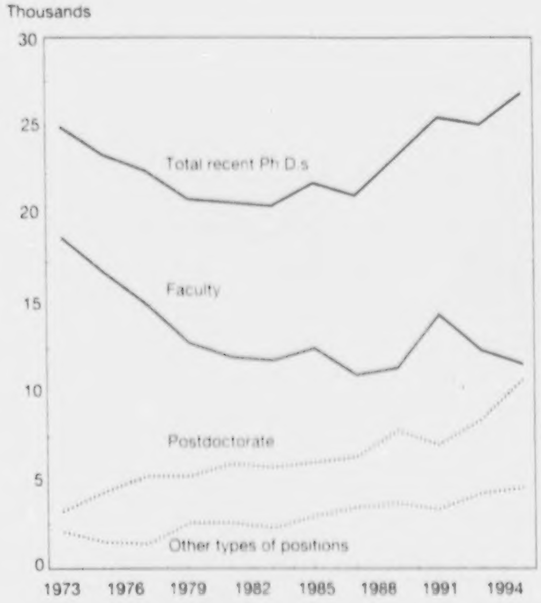
[41] No trend data exist on detailed in- and outflows. The data reported here are "snapshots" of the number and demographic characteristics of doctorate-holders in academic employment who had earned their degree in the three years preceding the survey.

Figure 5-15.
Number of recent Ph.D.s in academic S&E, by type of position



NOTES: Recent Ph.D.s are those who have earned their doctorate in the preceding three years. Faculty positions include full, associate, and assistant professor and instructor.

See appendix tables 5-29 and 5-30.

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percent in 1995.[42] The proportion of doctorates in other nonfaculty appointments has also doubled, rising from 8 to 17 percent. (See appendix table 5-30.)

The *demographic composition* of these recent academic doctorate-holders has shifted noticeably over two decades. The proportion of women has risen from 12 to 38 percent. The proportion of underrepresented minorities has grown from 2 to 7 percent, and of Asians from 5 to 23 percent. (See text table 5-7 and appendix table 5-30.) The *field composition* of young Ph.D.s reflects the larger employment changes: 38 percent are in the life sciences (up from 28 percent in 1973), 14 percent are in the physical sciences (after dropping from 16 in 1973 to 11 percent in 1985), and 4 percent are in mathematics (down from 9 percent in 1973). But the field distribution of young Ph.D. recipients in full-time faculty positions differs from this total employment picture, with smaller faculty shares in the physical and life sciences and higher fractions in psychology and the social sciences. (See appendix table 5-29.)

Research and Teaching Activities[43]

In the academic workplace, particularly in universities with a strong research orientation, teaching, research, and research training are often inextricably intertwined. In this way, academic research produces both new knowledge *and* highly trained personnel. Most academic scientists and engineers do not do *either* teaching or research, but pursue *both* activities in a mix that may change with the time of year and the course of their careers. Nevertheless, for the past two decades, a reasonably consistent indicator of the relative balance between teaching and research may be obtained from responses of academic doctoral scientists and engineers to a question about their major work responsibilities. The discussion here commences with an examination of a snapshot of the distribution of research and teaching activities, including undergraduate and graduate teaching, in academia; proceeds to trends in respondents' *primary* work responsibility; and closes by focusing on trends in primary and secondary responsibilities.

While not directly addressing the synergy between teaching and research, a survey (NSOPF) conducted by the U.S. Department of Education allows examination of the patterns of undergraduate and graduate teaching activities of doctoral academic scientists and engineers, and the extent of their research activities in relation to these teaching duties.

Of the estimated 213,800 doctoral scientists and engineers employed in academic institutions in 1993, 81 percent had some teaching duties in the fall semester of that year: 58 percent taught courses primarily for undergraduates, 25 percent taught courses primarily for graduate students, and 17 percent taught both graduate and undergraduate courses. (See text table 5-8.)

Those who taught undergraduate courses exclusively on average spent an estimated 65 percent of their weekly work time on teaching activities and 22 percent on research. For those with only graduate teaching responsibilities, the corresponding time estimates were 34 and 38 percent, respectively; and for those teaching both undergraduate and graduate

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[42] An accurate count of postdoctorates is elusive, and the reported increase may be understated. A postdoctoral appointment is defined here as a temporary position awarded primarily for gaining additional training in research. The actual use of the term, however, varies among disciplines and sectors of employment. In academia, some universities appoint postdoctorates to junior faculty positions which carry fringe benefits; in others, the appointment may be as a research associate. Some postdoctorates thus may not regard themselves as genuinely "employed." Also see "Postdoctoral Appointments" in chapters 2 and 3.

[43] This material is based on individual respondents' reports of their primary and secondary work responsibilities. The data series—which is drawn from SDR—is reasonably consistent for the 1973-89 period: respondents were asked to designate primary and secondary work responsibilities from a list of items, the majority of which remained unchanged. Since 1991, however, primary and secondary work responsibilities have had to be inferred from reports of the activities on which respondents spent the most and second-most amount of their average weekly work time. These two methods yield close—but not identical—results, so the SDR series must be considered a rough indicator only. In addition, some nonrespondents in 1981-87 were sent a shortened version of the questionnaire that did not ask about secondary work responsibility. For these respondents and these years, secondary work responsibility was estimated using full-form responses, based on field and type of position held. This analysis also draws on data from the 1988 and 1993 NSOPF. As noted in "Data Sources: Nature, Problems, and Comparability," the sample estimates of numbers of faculty from this survey differ slightly from those derived from SDR.

Text table 5-8.
Teaching and research activities of academic doctoral scientists and engineers

Surveyed doctoral scientists & engineers	Thousands	Percentage	Average percentage of time spent on:	
			Teaching	Research
1988 survey				
Total with teaching responsibilities[a]	176.1	100	50	27
Teaching undergraduates only	88.3	50	58	20
Teaching graduate students only	57.1	32	35	38
Teaching both	30.6	17	52	25
1993 survey				
Total with teaching responsibilities[a]	173.4	100	50	25
Teaching undergraduates only	100.0	58	65	22
Teaching graduate students only	43.9	25	34	38
Teaching both	29.6	17	50	27

NOTE: Total is based on all survey respondents with a doctorate in a science or engineering field.

[a]Data include all respondents who indicated that the number of students they taught was greater than zero.

SOURCE: U.S. Department of Education, National Survey of Postsecondary Faculty, 1988 and 1993; unpublished tabulations by the National Science Foundation.

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students, the percentages were 50 and 27. These time estimates have not changed greatly since 1988.[44]

Primary Work Responsibility: Emphasis on Research

SDR respondents (see "Data Sources: Nature, Problems, and Comparability") were asked to select their primary work responsibility from a list that includes teaching, various R&D functions, administrative work, consulting, and other activities. A crude but consistent indicator of the relative emphasis on research can be constructed from the responses. The choices in research activities as primary work responsibility reveal two major shifts. First, the relative balance between teaching and research has shifted toward the latter. Second, by this measure, growth of the research function has been especially pronounced outside the ranks of the traditional research universities.

The number of those reporting *teaching* as their primary work responsibility rose from 73,300 in 1973 to 101,100 in 1985 and has fluctuated around the 100,000 mark since then. In contrast, the number of those identifying *research* as their primary work responsibility has increased steadily, rising from 27,800 in 1973 to 56,000 in 1985 and 83,000 by 1995. These divergent trends have lowered the proportion of those reporting teaching as their primary work from 62 percent in 1973 to 46 percent in 1995, while the proportion of those reporting research as their primary work has risen from 24 to 38 percent. Those with other types of primary work responsibility—for administrative or managerial functions, service activities, and the like—constituted between 14 and 19 percent of the total over the period. (See appendix table 5-31.)

Employment growth in research universities since the late 1970s has been largely confined to those identifying research as their primary activity. Their number stood at 17,500 in 1973 and 45,900 in 1995, as their share rose from 30 to 51 percent of research universities' doctoral S&E workforce. In contrast, the number of research university faculty for whom teaching was the primary activity rose from 32,300 in 1973 to a high of 39,600 in 1981 before declining to 30,500 in 1995. The number identifying other functions as their primary work responsibility has remained at around 12,000 to 15,000 since the early 1980s. In other types of universities and colleges, a growing number of faculty identified teaching as their primary work activity for much of the two decades; since 1989, this number has fluctuated between roughly 67,000 and 70,000. But those for whom research was the primary work responsibility increased more rapidly and continuously. As their numbers grew from 10,300 in 1973 to 37,100 in 1995, their share rose from 17 to 29 percent. (See appendix table 5-31.)

Besides these institutional differences, there have been field differences as well. (See text table 5-9.) Employment growth from 1973 to 1995 has exceeded 50 percent in most fields,[45] except mathematics (41 percent) and—notably—the physical sciences (17 percent). Growth in *teaching* (as characterized here) was slower than overall employment growth in every field but the computer sciences; the physical sciences, by this measure, actually experienced negative growth. On the other hand, the number of respondents who designated *research* as their primary work responsibility

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[44] Those without fall 1988 teaching responsibility were ruled out of scope in that survey year, but not in 1993. The comparison with 1988 is based only on those 1993 respondents with teaching responsibilities.

[45] Computer science data were not broken out before 1979. The series starts from a very low base and involves a relatively small number of respondents. Thus, the percentage increases in computer science teaching versus research growth must be viewed in this context and are best interpreted only within the field.

Text table 5-9.

Percentage change in the number of academic doctoral scientists and engineers by reported primary work responsibility, by field: 1973-95

		Percentage change in faculty (from 1973-95):		
Field	Total	Reporting teaching as primary	Reporting research as primary	Reporting other work as primary
Total science and engineering	66	32	186	91
Sciences	64	30	175	97
Physical sciences	17	−12	128	76
Environmental sciences	56	26	213	54
Mathematics	41	25	89	137
Computer sciences[a]	328	437	221	267
Life sciences	79	26	165	113
Psychology	85	49	237	108
Social sciences	72	53	235	62
Engineering	78	42	314	49

NOTE: Primary work responsibility is defined by respondent's designation from 1973 through 1989; after 1989, primary work responsibility is defined by respondent's designation of activity consuming the most work time.

[a] The very large percentage increases in this field are based on a very small number of degree-holders in 1981.

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Doctorate Recipients, unpublished tabulations.

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quadrupled in engineering and more than tripled in several science fields. In mathematics and the physical sciences, it roughly doubled.

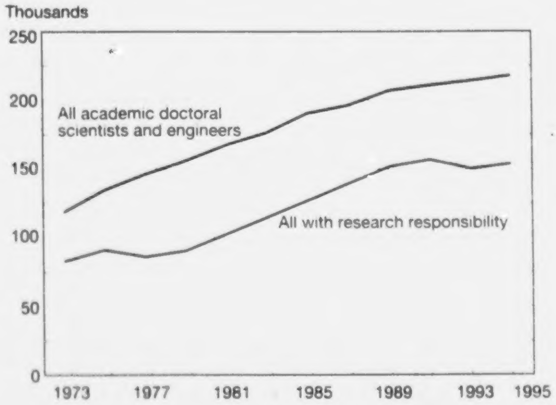
Participation in Research

Academic work generally entails a more complex mix of functions—teaching, research, administrative work, consulting, public service, among others—than the above-discussed indicator (research as primary work activity) takes into account. A more encompassing measure can be constructed from respondents' choice of research as *either* a primary or secondary work function; this yields a better lower bound estimate of the broadly defined academic doctoral research workforce.[46] By this measure, an estimated 153,500 academic doctoral scientists and engineers were engaged in R&D in 1995, up from a range of 80,000 to 90,000 during the 1970s.[47] (See figure 5-16.) The number of academic researchers has essentially been stable since the late 1980s, after strong growth in the preceding decade and a half. (See appendix table 5-32.)

Roughly 71 percent of all academic doctoral scientists and engineers reporting primary and secondary work responsibilities in 1995 were engaged in research activities, but this varied by field. At the high end—80 percent—were the environmental sciences; the life and computer sciences and engineering ranged from 75 to 78 percent. Those in the physical sciences, mathematics, psychology, and the social sciences reported the lowest levels of research activity, ranging from 62 to 70 percent.

Figure 5-16.

Academic doctoral scientists and engineers and those with research responsibility



NOTES: Research responsibility is reported as primary or secondary responsibility for R&D. The numbers for 1981-85 are extrapolated, since not all respondents were asked about their secondary work responsibility in those years.

See appendix table 5-32. *Science & Engineering Indicators – 1998*

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[46] The estimate fails to account for respondents who ranked research third or lower in their ordering of work responsibilities. Additionally, for 1981 through 1985, some respondents who received short forms of the survey questionnaire could not record a secondary work responsibility, thus resulting in a definite undercount for these years. All estimates are calculated based on individuals who provided valid responses to this item.

[47] A rough estimate of the nondoctoral researcher component, excluding graduate research assistants, was derived for 1993 from NSOPF. This study suggests that this component is approximately 10 percent the size of the doctoral research workforce and is concentrated in the medical and health sciences (60 percent), biological sciences (15 percent), and engineering (10 percent).

These field differences in the levels of research intensity have been fairly consistent over time, and the field composition of academic researchers has generally not shifted dramatically. But the relative employment shift noted earlier away from the physical sciences and toward the life sciences is evident in the research workforce as well. The physical science share has declined by 6 percentage points since 1973, and that of the life sciences has increased by 3 percentage points, with marginal gains or losses for the other fields. (See appendix table 5-32.)

Federal Support of Academic Researchers

In 1995, 39 percent of the academic doctoral scientists and engineers responding to SDR reported receiving funding from the Federal Government during the week of April 15. (See text table 5-10.) This number cannot be easily compared with those from earlier years, which were based on a year-long reference period—49 percent in 1989, 50 percent in 1991—but is in line with SDR estimates for other reference periods shorter than a full year: 37 percent each in 1985 and 1993. If the volume of academic research activity is not uniform over the entire academic year, but varies to accommodate teaching and other activities, a one-week or one-month reference period may well understate the extent of support over an entire academic year. Several pieces of evidence suggest this to be the case.[48]

Just over half (51 percent) of the doctoral scientists and engineers surveyed in the 1993 NSOPF reported having Federal Government funding in the fall semester of that year. This is in line with earlier SDR estimates based on year-long reference periods. The NSOPF estimate, when taken together with information regarding growth in federal funding, suggests that no major changes have occurred since the late 1980s in the number or proportion of researchers supported with federal funds. This tentative conclusion is further bolstered by the steady growth in the number of federally funded research assistants through the 1980s and 1990s.

Notable and persistent field differences exist in the proportion of researchers supported by federal funds.[49] Above the overall S&E average are the life, environmental, and physical sciences and engineering. Clearly below the mean are mathematics, psychology, and the social sciences. The relative position of these fields has not changed substantially over the past two decades. (See text table 5-10.)

Since the late 1980s, a larger fraction of academic researchers has reported federal support from more than one agency. This trend can be observed across most S&E fields. (See appendix table 5-33.) Fields with the highest levels of researchers receiving multi-agency support are the environmental sciences—more than 40 percent—and engineering and the computer and physical sciences—well above 30 percent for each. Single-agency support is most prominent in the life and social sciences, psychology, and mathematics. However, no clear upward trend in multi-agency support is evident since the late 1980s.

Text table 5-10.
Percentage of academic doctoral scientists and engineers reporting federal R&D support, by field

Field	1973	1975	1977	1979	1981	1983	*1985*	1987	1989	1991	*1993*	*1995*
Total science and engineering	46	42	41	39	42	44	*37*	48	49	50	*37*	*39*
Sciences	45	41	40	38	41	43	*36*	47	48	49	*36*	*38*
Physical sciences	49	45	46	44	50	51	*43*	54	58	56	*46*	*48*
Environmental sciences	47	46	43	45	49	54	*51*	60	63	65	*51*	*54*
Mathematics	29	19	19	21	21	30	*21*	31	33	34	*19*	*22*
Computer sciences	NA	NA	NA	35	30	45	*45*	62	52	49	*40*	*43*
Life sciences	60	59	57	55	59	59	*53*	65	65	65	*52*	*52*
Psychology	39	36	33	32	32	30	*25*	31	35	35	*26*	*27*
Social sciences	26	24	23	20	21	24	*17*	27	28	28	*14*	*16*
Engineering	55	50	51	49	50	55	*42*	57	56	63	*43*	*50*

NA = not available

NOTES: Data are based on respondents who answered "yes" or "no" to a question on whether they received federal support. Data for 1985 (italicized), which specified a reference period of one month, and for 1993 and 1995 (also italicized), which specified a one-week reference period, are not comparable to data from other years. Due to the nature of academic research funding, percentages in these years will tend to understate the proportion with federal support during an entire academic year.

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Doctorate Recipients, unpublished tabulations.

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[48] Indirect evidence that the extent of support is understated can be gleaned from the number of senior scientists and postdoctorates supported on NSF grants. This number is published annually as part of NSF's budget submission. It bears a relatively stable relationship to numbers derived from SDR in 1987, 1989, and 1991, but diverges sharply in 1993. (The figures from the two data sources are never identical, however, since NSF's numbers reflect those funded in a given fiscal year, while SDR numbers reflect those who have support from NSF regardless of when awarded.)

[49] The relative field shares of federally supported researchers appear to be stable across recent survey years, i.e., they are relatively unaffected by changes in the survey reference period. The distribution (but not the estimated number) based on NSF estimates is quite similar.

The interpretation of these data is ambiguous. They could, for example, indicate greater difficulty in obtaining funding, the growing availability of multiple funding sources, or increasing entrepreneurism by investigators in seeking out funding.

Integration of Research With Graduate Education

Science and engineering graduate students have a fairly unique role as both an input to and an output of the U.S. academic research system. U.S. research universities have traditionally coupled advanced education with research, both generating new knowledge and producing advanced scientific and engineering talent. This integration of research and advanced training in S&E is encouraged because the system has served the country well. U.S. research universities attract graduate students from across the nation and around the world. Upon receipt of their advanced degrees, these students set out to work in many sectors of the U.S. economy, using the skills and knowledge they have acquired to meet a broad range of challenges.

It is difficult to determine the exact number of S&E graduate students who are participating directly in the research process at their universities in a given year. Obviously, those students who are supported primarily through research assistantships are participating in research. Many of the students who are supported with other modes of support such as traineeships and fellowships are also likely to be directly involved in research activities at their institutions. And even students who are self-supported or are on teaching assistantships may be involved in research, at least part of the time. Any student who is working on a doctoral dissertation is expected to be doing research; in many cases, those working on master's theses are also expected to be doing research.

This section examines the sources and mechanisms of support for full-time S&E graduate students. Since the number of students supported by a research assistantship in any year is probably a lower bound for the number of S&E graduate students participating in research activities at U.S. universities, special emphasis is given to the role of the research assistantship. For a more in-depth treatment of graduate education, see chapter 2.

Support of S&E Graduate Students[50]

Trends in Support

In 1995, for the first time in almost two decades, enrollment of full-time S&E graduate students declined slightly. A 12-year trend of steady increases in enrollment of full-time graduate students whose primary source of support was the Federal Government also ended, as did an even longer upward trend in the number of graduate students whose primary source of support was from nonfederal sources.[51] The number of self-supported graduate students—that is, those whose largest source of support comes from loans or from personal or family financial contributions—also declined for the first time since 1988. (See appendix table 5-34.) It is too early to tell whether the 1995 enrollment decline is the beginning of a trend or simply a one-time drop. Preliminary evidence indicates, however, that this is not a one-time phenomenon, but rather part of a longer decline. For example, first-time enrollments of full-time S&E graduate students declined in both 1994 and 1995, and preliminary estimates from the 1996 Graduate Student Survey indicate that overall full-time enrollment dropped again in 1996.

Since 1980, there have been significant shifts in the relative usage of different types of primary support mechanisms. (See figure 5-17.) These shifts have been due more to rapid growth in some support mechanisms than to an absolute decline in the number of students supported by any of these mechanisms. In the past several years, concern has been voiced in a number of places about the value of different modes of support for S&E graduate students and whether the Federal Government and other providers of financial assistance should consider shifting the mix of their support (COSEPUP 1995 and NSF 1996d). For a summary of these discussions, see "Concern About Forms of Support for S&E Graduate Students."

The proportion of graduate students with research assistantships as their primary support mechanism increased from 22 to 27 percent between 1980 and 1995. This increase was offset by a drop in the proportions of students supported by traineeships (from 7 to 5 percent) or by teaching assistantships (from 23 to 20 percent). Most of these changes had occurred by the late 1980s, with proportional shares being relatively stable during the first half of the 1990s.

These overall shifts in support mechanisms between 1980 and 1995 occurred for both students supported primarily by federal sources and for those supported by nonfederal sources (this excludes students whose primary source of support is

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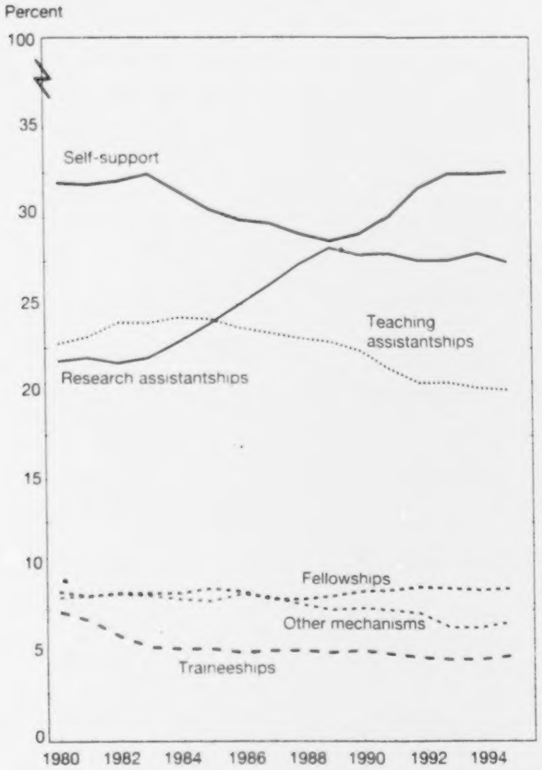
[50] All the data presented on mechanisms and sources of support for S&E graduate students in this and subsequent sections of this chapter are from the NSF-NIH annual fall survey of Graduate Students and Postdoctorates in Science and Engineering, unless otherwise indicated. In this survey, departments report the primary (largest) source and mechanism of support for each full-time degree-seeking S&E graduate student. No financial support data are collected for part-time students. Many of the full-time students may be seeking master's degrees rather than Ph.D. degrees, particularly in fields such as engineering and the computer sciences. Sources of support include federal agency support (from NIH, other HHS entities, NSF, DOD, or USDA); nonfederal support; and self-support. Support mechanisms include fellowships, traineeships, research assistantships, teaching assistantships, and other. Note that despite this section's emphasis on primary source and primary mechanism of support, most graduate students are supported by more than one source and one mechanism during their time in graduate school, and that individual graduate students often receive support from several different sources and mechanisms in any given academic year. Throughout this section, S&E includes the health fields (medical sciences and other life sciences).

[51] Total federal support of graduate students is underestimated since reporting on federal sources includes only direct federal support to a student and support to research assistants financed through the direct costs of federal research grants. This omits students supported by departments through the indirect costs portion of research grants; such support would appear as institutional (nonfederal) support, since the university has discretion over how to use these funds.

Figure 5-17.
Support for full-time S&E graduate students



NOTE: S&E includes the health fields (medical sciences and other life sciences).

See appendix table 5-34. *Science & Engineering Indicators – 1998*

self-support). Among students whose primary source of support was the Federal Government:

- the proportion of those whose primary mechanism of support was a research assistantship increased from 55 to 66 percent.
- the proportion whose primary mechanism was a traineeship decreased from 25 to 15 percent, and
- those with fellowships as their primary support mechanism fluctuated between 8 and 12 percent of the total over this period.

The Federal Government has an almost negligible role in supporting teaching assistantships.

Among students whose primary source was nonfederal:

- research assistantships rose from 20 to 29 percent,
- teaching assistantships fell from 48 to 42 percent,
- fellowships fluctuated between 13 and 14 percent, and
- traineeships ranged between 3 and 4 percent of the total.

Patterns of Support by Institution Type

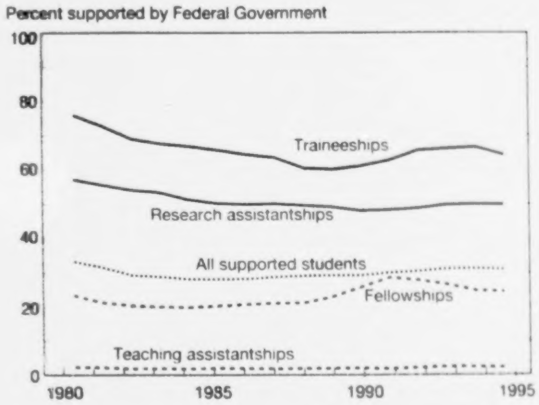
The proportion of full-time S&E graduate students with primary support from various sources and mechanisms differs for private and public universities. (See appendix table 5-35.) A larger proportion of full-time graduate students relies primarily on self-support in private academic institutions as opposed to those in public institutions—39 versus 30 percent in 1995.

Nonfederal sources are the primary source of support for a larger proportion of students in public institutions (50 percent) than in private ones (41 percent). For both private and public institutions, about 20 percent of students receive their primary support from the Federal Government.

A larger proportion of students attending public academic institutions relies on research assistantships and teaching assistantships as their primary support mechanism (30 percent and 23 percent, respectively) than those attending private institutions (21 percent and 13 percent, respectively). This is balanced by greater reliance on fellowships and traineeships in private institutions (14 percent and 8 percent, respectively) than in public ones (7 percent and 4 percent, respectively).

The Federal Government plays a larger role as the primary source of support for some mechanisms than for others. (See figure 5-18.) A majority of traineeships in both private and public institutions (53 percent and 73 percent, respectively) is financed primarily by the Federal Government, as are 60 percent of the research assistantships in private institutions and 47 percent in public institutions. The Federal Government provides the primary support for less than 30 percent of fellowships and less than 2 percent of teaching assistantships in both public and private institutions.

Figure 5-18.
Percentage of full-time S&E graduate students with Federal Government as primary source of support, by primary mechanism of support



NOTES: Data shown here do not include students for whom self-support is their primary source of support. S&E includes the health fields (medical sciences and other life sciences).

See appendix table 5-34. *Science & Engineering Indicators – 1998*

Concern About Forms of Support for S&E Graduate Students

Although there is general agreement that students in S&E disciplines who obtain Ph.D.s from U.S. research-oriented universities are among the best prepared and most successful scientists and engineers in the world, some believe that the challenges of educating scientists, mathematicians, and engineers for the 21st century mandate a new paradigm in graduate training. They contend that doctoral programs could better prepare students for careers outside of academe or basic research by ensuring that they are versatile rather than narrowly specialized and that they are equipped with skills, such as interpersonal communication and the ability to work well in teams, that will enhance their ability to succeed in the real world.

The Committee on Science, Engineering, and Public Policy of the National Academy of Sciences in a report released in 1995, *Reshaping the Graduate Education of Scientists and Engineers*, focuses on Ph.D.s and discusses the changing context of graduate education and the employment trends and prospects for the employment of graduate scientists and engineers. One of the report's major recommendations is: "to foster versatility, government and other agents of financial assistance for graduate students should adjust their support mechanisms to include new education/training grants to institutions and departments." The authors feel that research assistantships, although they offer educational benefits in the form of research skills, focus doctoral programs on the needs of research projects rather than on the broader educational needs of the students.

In June 1995, the Mathematical and Physical Sciences Directorate (MPS) of the National Science Foundation planned and hosted a conference on education and employment patterns of graduates in the mathematical and physical sciences. Conference participants endorsed the following recommendations: (1) mechanisms should be found to encourage a broadening of the training and education experience of MPS graduate students; (2) mechanisms should be examined for shortening the average time to Ph.D. degree in MPS fields; (3) the use of off-campus experience, such as industrial internships, should be increased; and (4) efforts should be made to decrease gradually the proportion of graduate students funded as research assistants and to increase gradually the proportion funded by other mechanisms, including traineeships and fellowships, as well as novel, collective modes of support (NSF 1996d).

The National Science Board Task Force on Graduate Education was established in June 1995 to examine the merits and mix of the several modes of funding support (e.g., research assistantships, fellowships, traineeships) used by NSF to support graduate and postdoctoral education, and the impact of the various modes of support on the experience and preparation of those supported. The members concluded that sufficient data linking both the national data and NSF support data did not exist to make recommendations for major revisions in the mix of NSF funding. Their report (NSB 1996)—delivered in February 1996—did, however, endorse: (1) limited studies on alternative modes of graduate support with defined goals and assessment criteria; and (2) data collection and/or research on funding mechanisms and various aspects of graduate student education and employment.

As part of the call for changes in the manner in which S&E graduate students are supported, the merits of various support mechanisms have been discussed and a number of hypotheses developed about the advantages and disadvantages of different mechanisms. In fact, some of the characteristics of a specific mechanism that are cited as disadvantages by some individuals are cited as advantages by others. For instance, the portability of fellowships and the independence they give to graduate students are seen by some as a distinct advantage because they provide these students with a lot of freedom to pursue a wide variety of interests. Others argue that students with fellowships are more likely than those being supported by traineeships or research assistantships to become isolated from their peers and from the faculty in their departments, and thus may either be less likely to complete their Ph.D. or to take longer to do so. Some argue that although having a fellowship at the beginning of a graduate career may be detrimental, having one when working on a dissertation is highly advantageous.

Similarly, some argue that since research assistantships are directed to the needs of funded research projects, doctoral students can become so involved on a specific project that they have little time for independent exploration or other educational activities, thus limiting the areas in which they acquire experience. A counterargument is that the skills and experience students acquire by focusing on a specific research project are indispensable to the high-quality, state-of-the-art research being conducted at U.S. universities and industrial laboratories. Some argue that strong reliance on research assistantships can bias research and graduate training toward those areas that have long track records rather than to new and exciting areas and that they also may prevent beginning faculty from attracting graduate students. Others argue that it is the widespread availability of research grants that provides young faculty with the opportunity to work closely with graduate students.

Unfortunately, it is extremely difficult to examine many of these hypotheses analytically either because of the absence of data or the inability to capture the hypothesized outcomes quantitatively. In addition, most graduate students depend on multiple sources and mechanisms of support while they are in graduate school, and frequently on different sources and mechanisms of support in different phases of graduate work. This makes it quite difficult, if not impossible in many cases, to identify a one-to-one relationship between a student and a support source or mechanism.

Support Patterns for All S&E Graduate Students Versus Doctoral Recipients[52]

Most S&E graduate students do not go on to receive a Ph.D. It is thus useful to compare the support patterns of those students who *do* earn a Ph.D. with the patterns for all full-time S&E graduate students to see if they differ significantly. Twenty-nine percent of the students receiving Ph.D.s in science and engineering in 1995 reported that their primary mechanism of support during their time in graduate school was a research assistantship. This is close to the percentage (27 percent) of full-time S&E students for whom a research assistantship was reported as the primary mechanism of support. Fellowships and teaching assistantships were reported less frequently as a primary mechanism of support by those students who earned an S&E Ph.D. (2 percent and 6 percent, respectively) than for all full-time S&E graduate students (9 percent and 20 percent, respectively). Traineeships, however, were reported more frequently by those receiving an S&E Ph.D. (13 percent) than for graduate students in general (5 percent). A considerably smaller percentage of students receiving an S&E Ph.D. reported self-support as their primary means of support (18 percent) than did graduate students in general (32 percent). (See appendix tables 5-36 and 5-37.)

Anecdotal evidence suggests that students are more likely to be teaching assistants in the early stages of graduate school when they are doing their coursework than in the later stages when they are working on a doctoral dissertation. Therefore, if students receiving Ph.D.s are more likely to report those mechanisms that supported them in the later years of graduate school as primary, it might explain the small percentage reporting teaching assistantships as a primary support mechanism.

Research Assistantships as a Primary Mechanism of Support

Graduate RAs by S&E Field

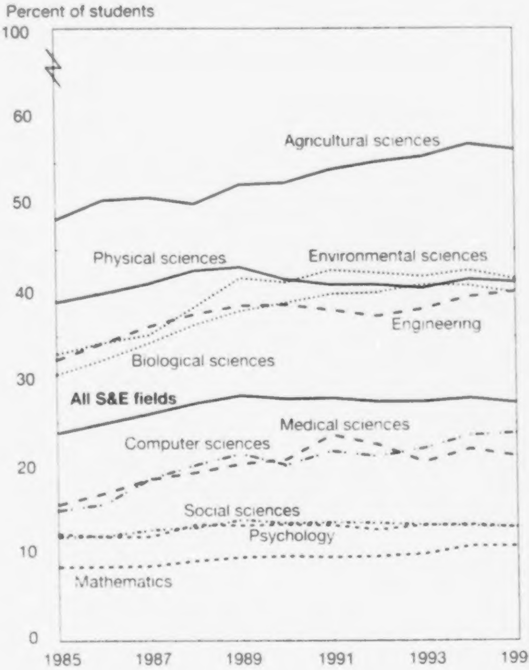
As indicated previously, research assistantships account for 27 percent of all support mechanisms in 1995. However, the mix of support mechanisms—and thus the role of RAs as the primary support mechanism—differs by S&E field. (See appendix table 5-37.) RAs comprise more than 50 percent of the primary support mechanisms for graduate students in astronomy, atmospheric sciences, oceanography, agricultural sciences, chemical engineering, and materials engineering. They account for less than 20 percent in the social sciences, mathematics, and psychology.

The overall number of graduate students with an RA as their primary mechanism of support increased every year between 1985 and 1994 before declining slightly in 1995. (See appendix table 5-38.) Most S&E fields exhibited similar trends, although not all showed a decline in 1995. In just about every S&E field, the percentage of graduate students with an RA as their primary means of support was higher in 1995 than in 1985. The largest increases were in the atmospheric sciences (13 percent), electrical/electronic engineering (12 percent), civil engineering (10 percent), computer sciences, earth sciences, biological sciences, and industrial engineering (all 9 percent). (See figure 5-19.)

All S&E Graduate Students Versus Doctoral Recipients

The relative utilization of an RA as a primary mechanism of support was also fairly consistent at a broad disciplinary level between the Ph.D. and graduate student surveys. (See figure 5-20.) Research assistantships were once again quite prominent in the physical sciences, environmental sciences, and engineering; and were of much less prominence in mathematics, the social sciences, and psychology, confirming the earlier results.

Figure 5-19.
Percentage of full-time S&E graduate students with a research assistantship as primary mechanism of support, by field



See appendix table 5-38.

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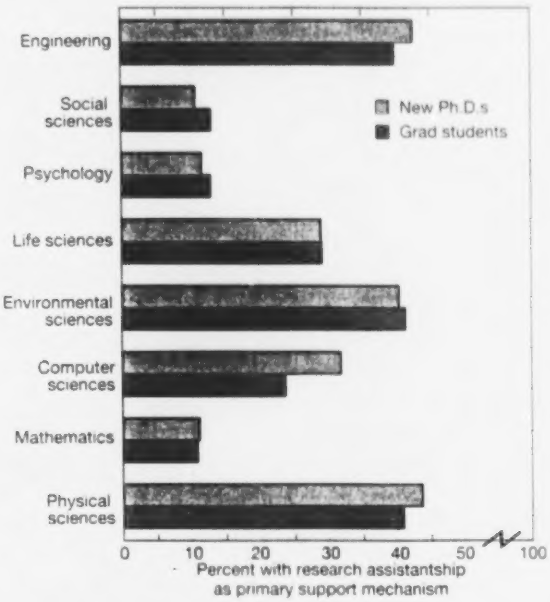
[52] Another source of data on sources and mechanisms of financial support of S&E graduate students is the annual Survey of Earned Doctorates. Students who have just received their Ph.D.s are asked to respond to this survey. One survey question asks them to identify their primary and secondary sources of support during graduate school as well as to check all other sources from which support was received. Validation studies on the quality of the data received from respondents to this survey indicate that the information on mechanisms of support is much better than that on sources. This is especially true for students whose primary support is a research assistantship since they may not always know who is providing the funds that are supporting them. For this reason, the comparison between the graduate student survey and the doctorate survey is confined to mechanisms of support except for self-supported students.

Figure 5-20.
Relative importance of research assistantships as primary mechanism of support for full-time S&E graduate students and new S&E Ph.D.s, by field: 1995



NOTE: Life sciences includes the health fields (medical sciences and other life sciences).

See appendix tables 5-36 and 5-37.

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Sources of Support

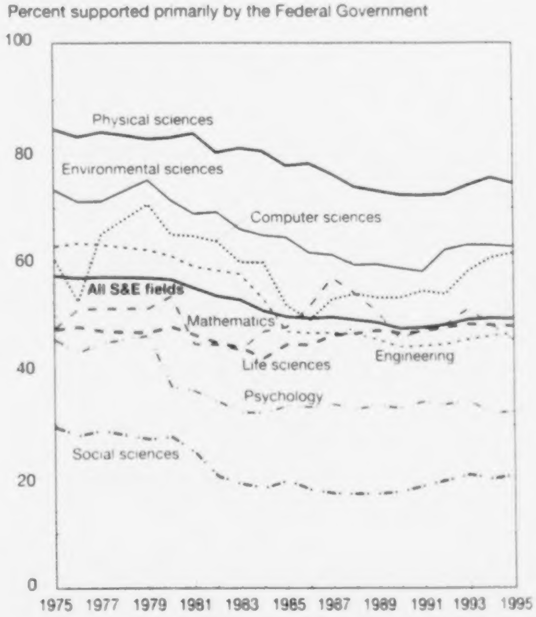
In 1995, about one-third of graduate research assistants were in the life sciences, with an additional 30 percent in engineering and 13 percent in the physical sciences. The Federal Government was the primary source of support for about half of all graduate students with an RA as their primary mechanism of support. (See appendix table 5-39.) The Federal Government was the primary source of support for significantly more than half of the research assistants in the physical sciences (75 percent), the environmental sciences (63 percent), and the computer sciences (62 percent); and for considerably less than half in the social sciences (20 percent) and psychology (32 percent). The proportion of graduate research assistants for whom the Federal Government was the primary source of support declined from 58 percent in 1975 to about 50 percent in 1985, where it has remained pretty much through 1995. Similar trends held for the environmental sciences, psychology, social sciences, medical sciences, and engineering. The physical sciences were more variable: chemistry and physics had declining federal shares in both 10-year periods, but astronomy showed little change in the first decade and a considerable decline in the second. The federal share of research assistants in the computer sciences declined from 61 to 49 percent between 1975 and 1986 and then proceeded to increase once again to 62 percent by 1995. (See appendix table 5-40 and figure 5-21.)

Federal Agency Support[53]

From the early 1970s to the late 1980s, NSF was the federal agency that was the primary source for the largest number of graduate RAs. It was surpassed by HHS (as a whole) in 1989 and by NIH in 1993. Between 1972 and 1995, the percentage of federal graduate RAs financed primarily by NSF declined from one-third to less than one-quarter, while the percentage financed primarily by NIH increased from one-sixth to one-quarter. The DOD share has fluctuated between 10 and 16 percent over the period. (See appendix table 5-41.)

Just as federal agencies emphasize different S&E fields in their funding of academic research, they also emphasize

Figure 5-21.
Percentage of research assistants whose primary source of support is the Federal Government, by field



NOTES: Research assistants are students for whom a research assistantship is reported as their primary mechanism of support. Life sciences includes the health fields (medical sciences and other life sciences).

See appendix table 5-40.

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different fields in their support of graduate research assistants. HHS and especially NIH concentrate support in the life sciences (53 and 72 percent, respectively); as does USDA (72 percent). DOD concentrates its support in engineering (55 percent). NSF, on the other hand, has a more diversified support pattern, with one-third in engineering, 30 percent in the physical sciences, and 12 percent in the environmental sciences. (See figure 5-22 and appendix table 5-42.)

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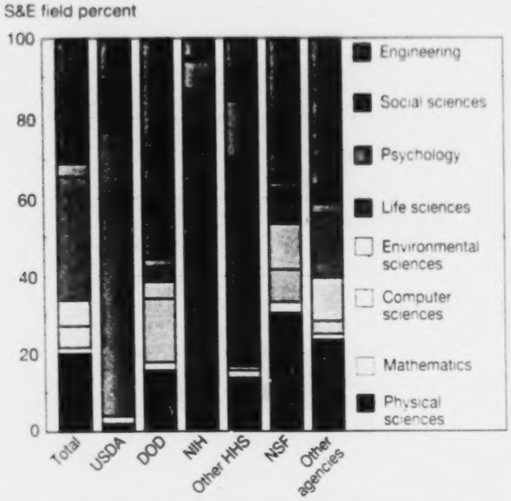
[53] Only four federal agencies are reported on individually as primary sources of support to S&E graduate students in the Survey of Graduate Students and Postdoctorates in Science and Engineering: DOD, NSF, USDA, and HHS; the latter is reported as two distinct units—NIH and other HHS. NASA has been added to the 1996 survey.

Although an agency may place a large share of its support for research assistants in one field, it may not necessarily be an important contributor to that field overall, particularly if it is a small agency in terms of its support for graduate research assistants. (See figure 5-23 and appendix table 5-43.) NSF is the lead supporting agency in mathematics (44 percent of federally supported RAs), the environmental sciences (42 percent), the physical sciences (37 percent), and engineering (29 percent). NIH is the lead support agency in the life sciences (58 percent), psychology (54 percent), and sociology (31 percent). DOD is the lead support agency in the computer sciences (43 percent) and—of those agencies included in the survey—in aeronautical/astronautical engineering (38 percent), electrical/electronic engineering (41 percent), and mechanical engineering (29 percent). USDA is the lead support agency in the agricultural sciences (61 percent) and economics (58 percent).

Figure 5-22.
Field distribution of research assistantships with primary support from a federal agency, by agency: FY 1995

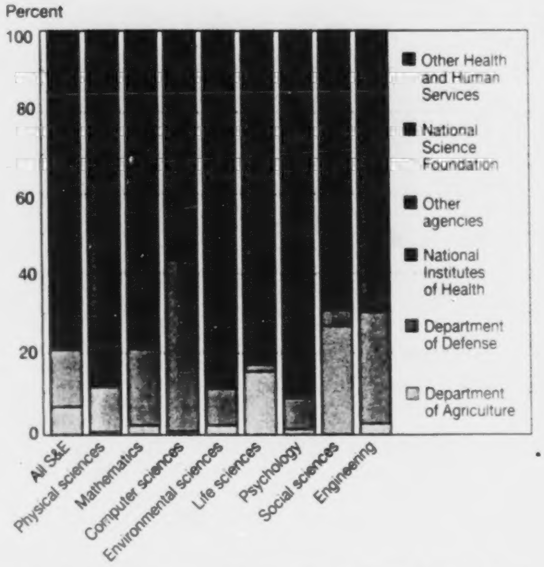


USDA = Department of Agriculture; DOD = Department of Defense; NIH = National Institutes of Health; HHS = Department of Health and Human Services; NSF = National Science Foundation

NOTES: The agencies cited here are the only ones for which graduate support data are reported in 1995. Life sciences includes the health fields (medical sciences and other life sciences).

See appendix table 5-42. *Science & Engineering Indicators – 1998*

Figure 5-23.
Research assistantships supported primarily by the Federal Government, agency shares by S&E field: FY 1995



NOTE: Life sciences includes the health fields (medical sciences and other life sciences).

See appendix table 5-43. *Science & Engineering Indicators – 1998*

The Spreading Institutional Base

Between 1979 and 1995, there was a slight increase in the number of universities and colleges reporting at least one RA as a primary mechanism of support for their S&E graduate students (385 to 415), with the number reaching its highest level (435) in 1993. Not surprisingly, however, there was basically no change in the number of research universities or doctorate-granting institutions reporting the presence of graduate RAs during this period; this number fluctuated between 219 and 224. Since these institutions had probably been receiving research funds over the entire period, it is likely that they were supporting graduate students with research assistantships. Thus, most of the fluctuation and the entire increase in the number of institutions reporting graduate RAs occurred among comprehensive; liberal arts; two-year community, junior, and technical; and professional and other specialized schools. (See text table 5-11.)

The data suggest that most of the increase in the number of institutions reporting RAs as a mechanism of support for their S&E graduate students is due to increasing support from nonfederal sources—probably from the institutions themselves—rather than from the Federal Government.

In addition, throughout this period, considerably fewer institutions reported students with RAs financed primarily by the Federal Government than with assistantships financed primarily from nonfederal sources. This difference is par-

Text table 5-11.
Number of academic institutions reporting graduate research assistantships, by primary source of support and type of institution

Primary source of support and institution type[a]	Number of institutions reporting research assistantships																
	1979	1980	1981	1982	1983	*1984*	*1985*	*1986*	*1987*	1988	1989	1990	1991	1992	1993	1994	1995
All sources of support																	
All institutions	385	400	425	408	413	*332*	*324*	*318*	*320*	412	415	425	413	426	435	421	415
Research and doctorate-granting	220	222	223	224	224	*221*	*217*	*214*	*215*	224	221	222	222	219	222	219	220
Other	165	178	202	184	189	*111*	*107*	*104*	*105*	188	194	203	191	207	213	202	195
Nonfederal sources of support																	
All institutions	352	371	403	383	390	*321*	*310*	*307*	*306*	396	399	404	394	410	418	404	404
Research and doctorate-granting	211	217	218	218	216	*218*	*214*	*213*	*214*	221	221	221	221	218	221	216	219
Other	141	154	185	165	174	*103*	*96*	*94*	*92*	175	178	183	173	192	197	188	185
Federal sources of support																	
All institutions	297	297	316	308	296	*269*	*261*	*254*	*266*	292	299	302	303	305	312	312	303
Research and doctorate-granting	207	207	213	210	209	*210*	*204*	*197*	*200*	209	205	203	205	206	206	209	205
Other	90	90	103	98	87	*59*	*57*	*57*	*66*	83	94	99	98	99	106	103	98

NOTES: Numbers in italics (1984 to 1987) are not comparable with earlier or later years because only a sample of master's-granting institutions rather than the entire population was included in the survey during these years.

[a]These are the institutional categories used by the Carnegie Foundation for the Advancement of Teaching. See chapter 2, "Characteristics of U.S. Higher Education Institutions," for information on these categories. "Other" institutions are all Carnegie-classified institutions except research and doctorate-granting institutions.

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Graduate Students and Postdoctorates in Science Engineering, various years, unpublished tabulations.

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ticularly pronounced among the "other" Carnegie institutions, 98 of which report RAs supported by the Federal Government in 1995 compared to 185 that report RAs financed by nonfederal sources. Why so many fewer other institutions report the Federal Government as a primary source of funds for research assistantships than receive R&D funds from the Federal Government is unclear.

Outputs of Scientific and Engineering Research

The products of academic research, as noted elsewhere in this chapter, include trained personnel and advances in knowledge. The former have been discussed in chapter 3 of this volume and in the preceding sections of this chapter. This section deals with indicators of advances in knowledge—specifically:

1. The published outputs of natural science and engineering research in a set of refereed journals, discussed in terms of:
    - **the output volume of research**—by country and field and, in the case of the United States, by sector—using article counts as the indicator;
    - **patterns of research collaboration**—across national and, for the United States, sectoral boundaries—using multi-author articles as the indicator;
    - **the use of research outputs in subsequent scientific and engineering research**—again, international and intersectoral—using citation counts as the indicator; and
    - **the potential practical utility of these research outputs**, as indicated by citations to these articles on U.S. patents.
2. Patents issued to U.S. universities and colleges—i.e., the number and types of patents, institutions with patent awards, and revenue generated by patents and licenses.

Article Outputs

This discussion of article outputs places the United States in the context of other countries contributing to the world scientific literature and examines that literature by field.[54] For a description of the data used in this analysis and its limitations, see "Data Sources for Article Outputs."

U.S. Articles

In the United States, increased attention has been given to cross-sectoral collaboration in scientific and engineering research. Of particular interest has been the collaboration between industry and universities to enrich the research perspectives of investigators in both settings and to create a means for more efficiently channeling research results toward practical applications. This section discusses the sectoral distribution of U.S. articles, patterns of cross-sectoral collaboration and citation, and multidisciplinary connections of these articles.

Sectoral Distribution. About 142,800 scientific and technical articles were published by U.S. authors in 1995 in the set of 4,800 journals. Of these:

- 71 percent were academic publications;
- 8 percent each were produced by industry and the nonprofit sector (mainly health-related organizations publishing in the biomedical fields—i.e., biology, clinical medicine, and biomedical research); and
- 8 percent were produced by the Federal Government, with an additional 3 percent published by FFRDCs—these latter were mainly in the physical sciences and engineering.

These proportions represent a slightly enhanced position for academic publications since 1981 (68 percent) and an offsetting decline in the federal share including FFRDCs. (See appendix table 5-44.)

The number of *academic papers* increased in all fields but biology (down 25 percent since 1981) and mathematics (down 27 percent). The decrease in biology was partially offset by a strong increase in biomedical research articles, possibly reflecting a shift in focus. No ready explanation is evident for the decline in mathematics outputs. (See appendix table 5-45 for field taxonomy.)

Industry publishing has undergone considerable change over the period, reflecting both growing interest in the biomedical fields and a decline in some more traditional areas of industry activity. Industry publications almost doubled in clinical medicine and tripled in biomedical research; these two fields combined accounted for 4,700 industry articles—or 39 percent of this sector's total in 1995, versus 19 percent in 1981. Industry publications in physics, chemistry, and engineering and technology—fields traditionally emphasized in industrial research—as well as mathematics all declined in absolute numbers during the 1990s; engineering and technology suffered a particularly steep decline during the 1980s. The precise reasons for these declines are unclear, but they may in part reflect one outcome of the restructuring and refocusing of corporate R&D activities.[55] (See appendix table 5-44.)

Article production by the Federal Government fell and was steady overall for FFRDCs. Federal research output in biomedicine and chemistry was steady. Physics and earth and space sciences articles were up; but a declining output in clinical medicine, biology, mathematics, and engineering and technology outweighed these numerical increases. In the case of *FFRDCs*, increased publications in physics and earth and space sciences balanced declines in other fields. *Nonprofit organizations* increased publication in the biomedical fields, in which they have a combined 11 percent share. (See appendix table 5-44.)

Cross-Sectoral Collaboration. Scientific and engineering research in the United States increasingly involves investigators from several employment sectors, as evidenced by the steady increases in the number and proportion of articles with authors from more than one sector. This increase is evident for all sectors and for all fields—even those with declining output—except mathematics, where the modal pattern remains sole authorship.

Just under one-quarter (24 percent) of all academic papers published in 1995 involved collaboration with one or more authors from other sectors—6 percent from industry, 8 percent each from the Federal Government and not-for-profit sectors, 3 percent from FFRDCs, and 2 percent from other sectors.[56] While this proportion may appear low, it involved roughly 25,900 articles and represented an increase from 20 percent in 1981 (20,100 articles). (See appendix table 5-46.)

The propensity of scientists and engineers employed in other sectors to collaborate across sectoral boundaries was much higher than for their academic colleagues—50 percent in industry, 56 percent in FFRDCs, and 60 percent and above in the other sectors. Moreover, 1981-95 increases in cross-sectoral collaboration have been more pronounced in the nonacademic sectors, ranging from 7 percentage points for nonprofit institutions to 23 percentage points for industry. But most of the cross-sectoral collaborations involved one or more academic authors.

Intersectoral Citation Patterns. Research builds upon previous results, and references to scientific and technical articles reflect their utility in subsequent work. The distribution of such citations to U.S. scientific and technical articles largely—

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[54] This section discusses *all* article outputs produced, regardless of originating sector. Not all of these articles originated in the academic sector. However, 71 percent of them did in 1995, and many others involve collaboration with academic researchers or heavily cite the academic literature. Moreover, the non-U.S. literature cannot be cleanly broken out by performing sector.

[55] These declines apparently do not reflect a lack of coverage of newly established journals in the Institute of Scientific Information data set. They were checked against trends in the 1985 and 1991 ISI journal sets, and, while the absolute numbers varied across sets, the direction and relative rates of change for these industry fields were found to be very similar.

[56] These details add up to more than 24 percent because of the incidence of papers involving authors in three or more sectors.

Data Sources for Article Outputs

The article *counts* discussed in this section are based on scientific and engineering articles published in a stable set of about 4,800 journals selected by the Institute of Scientific Information (ISI) as the base for its Science Citation Index in 1981. Fields covered are clinical medicine, biomedical research, biology, physics, chemistry, earth and space sciences, mathematics, and engineering and technology. Appendix table 5-45 lists the constituent fine fields. A database covering the social sciences and behavioral aspects of psychology is being prepared for inclusion in future *Indicators* volumes. The database *excludes* letters to the editor, news pieces, editorials, and other content whose central purpose is not the presentation or discussion of scientific data, theory, methods, apparatus, or experiments.

ISI periodically updates its journal coverage, based in part on references to articles in publications not currently included in the database. Given this citations-based updating, ISI's database appears to give reasonably good coverage of a core set of scientific journals (albeit with some English-language bias), but not necessarily of all that may be of regional or local importance. This last point may be particularly salient for the engineering and technology category and for nations with a small or applied science base. In this discussion, *long-term publishing trends* including coauthorship patterns are based on a journal set established by ISI in 1981. *Citation trends* are based on a 1985 journal set. Of course, new journals are always being created, and old ones cease publication. No attempt has been made here to trace the birth and death of journals and their selection for coverage by SCI over the years. All data derive from the Indicators Bibliometrics database prepared for NSF by CHI Research, Inc.

Articles are attributed to sectors and countries by the authors' institutional affiliation, which introduces certain complexities and limitations. For example, a paper is considered to be multi-authored only if two or more authors have different institutional affiliations. The same rule applies to cross-sectoral or international collaborations. For example, a paper written by a U.S. citizen temporarily residing in the United Kingdom in collaboration with someone at his or her U.S. home institution is counted as internationally coauthored, thus possibly overstating the extent of such collaborations. On the other hand, a paper coauthored by a British citizen temporarily located at a U.S. university with another member of the faculty would not be considered internationally coauthored, thus understating the count.

but not entirely—reflects the distribution of the articles themselves, with the bulk of citations going to academic papers. The academic sector contributes 71 percent of all articles and receives 71 percent of all citations. Its citation frequency in clinical medicine, biomedical research, and mathematics is slightly below its publications share; in biology, chemistry, and engineering and technology, the citation frequency exceeds its publications share. (See appendix table 5-47.)

Industry articles are cited at a higher frequency than their share would suggest in the fields of physics and engineering and technology. In recent years, however, both of these fields have experienced a decline in the number of industry articles as well as a decline in the number of citations to these articles.

Linkages Among Disciplines. Research on many scientific challenges increasingly relies on the knowledge and perspectives of a multitude of disciplines and specialties. Biologists seeking to understand cell functions supplement techniques and approaches developed internally with others developed in engineering, chemistry, and physics. Citations in scientific and technical articles that cross disciplinary boundaries are one indicator of the multidisciplinary nature of the conduct of research. The citation patterns among Science Citation Index articles provide a glimpse of connections among major fields and fine fields.[57]

Citations in 1994-95 U.S. articles contained in SCI were aggregated by field.[58] Of the roughly 2.3 million references, articles in the three life sciences—which accounted for 63 percent of the U.S. output—contained 73 percent of the citations, those in other sciences and mathematics 25 percent, and engineering and technology articles just over 2 percent. The distribution of these citations across major fields shows the expected high incidence of references to articles in the same broad field, ranging from 69 to 83 percent in the physical and earth and space sciences to 62 percent in biology. Articles in the combined life science fields cited other life science articles 98 percent of the time. However, the citation patterns are not symmetrical. A greater proportion of citations in the physical sciences, mathematics, and engineering and technology focuses on the life science fields than vice versa. (See appendix table 5-48.)

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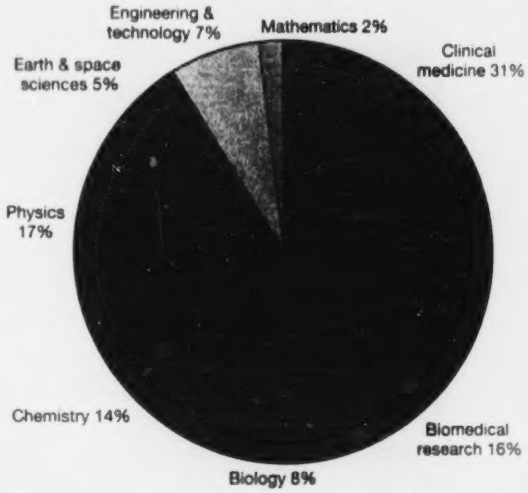
[57] Data for other indicators of multidisciplinary research activities are not readily available: collaboration of researchers across disciplinary boundaries, multidisciplinary centers, and major multidisciplinary projects—e.g., global climate research—lack readily available representative data or a ready framework for their analysis.

[58] Specifically, references in articles with one or more U.S. authors published in 1994-95 in journals covered by the 1985 SCI set that cited other U.S. articles published in 1990-93.

Examination of fine fields underscores the tight connections among the life science fields. Citations in clinical medicine and biomedical research articles are largely to other articles in these same major fields—90 percent or higher—with most of the remaining citations to biology. This does not mean that their research is isolated from other major fields. About 6,200 citations in clinical medicine and 20,000 in biomedical research articles were to physical sciences, engineering, or mathematics journals. But these represented tiny portions of their total citations—numbering 920,000 and 651,000, respectively. Pharmacy and pharmacology, for example, cite articles in chemistry journals; some biomedical specialties cite chemistry, physics, earth and space sciences, and engineering and technology. The earth and space sciences' connection to biomedical research is intriguing: 4 percent of astronomy/astrophysics citations were to this literature, which in turn received more than 200 citations from general biomedical research articles. These citation links reflect, among other things, the well-publicized adaptation of astronomy imaging techniques to medical diagnosis uses. Otorhinolaryngology articles contain references to the acoustics literature—physics—reflecting a similar connection. (See appendix table 5-48.)

Figure 5-24.
Distribution of articles in world scientific and technical journals, by field: 1995



See appendix table 5-49. *Science & Engineering Indicators – 1998*

Trends in International Article Production

The article counts reported here indicate the volume of scientific publishing in a given field and country, and the field mixes of different countries, as reflected in this set of core journals. In interpreting these counts, note that they reflect field-to-field and country-to-country variations in publishing conventions and differing sizes of scientific infrastructures. The discussion focuses on broad trends and relationships. (See "Data Sources for Article Outputs.")

Worldwide publication of scientific and technical articles in the SCI journal set stood at about 439,000 in 1995. (See appendix table 5-49 for detailed counts.) Almost one-third of these—135,000—were articles in clinical medicine; biomedical research and biology accounted for an additional 107,000 articles. Articles in chemistry, physics, and the earth and space sciences numbered 61,000, 74,000, and 23,000, respectively; there were 31,000 articles published in engineering and technology, and 8,000 in mathematics. (See figure 5-24.)

Five nations produced more than 60 percent of all articles in the SCI set of journals in 1995: the United States (33 percent), Japan (9 percent), the United Kingdom (8 percent), Germany (7 percent), and France (5 percent). No other country's output reached 5 percent of the covered articles' total. The regional distribution of these articles is shown in figure 5-25.

From 1981 to 1995, the number of articles published worldwide in the SCI journal set rose by almost 20 percent, compared with 8 percent in the United States alone.[19] This increase coincided with the development or strengthening of national scientific capabilities in several world regions, a development that was particularly pronounced after the end of the Cold War. Thus, a gradual decline in the U.S. world share since the early 1980s continued through the mid-1990s, despite continued growth in U.S. publications output. (See appendix table 5-49.) The European share rose from 32 to 35 percent over the period. It is likely that these gains partially reflect European nations' concerted policies to strengthen the science base in both individual countries and across Europe as a whole.

The article volume of the Central European states—Bulgaria, Czech Republic, Hungary, Poland, Romania, and Slovakia—as a group declined through the early 1990s but rebounded to close to its 1981 level by 1995 (9,100 articles). In contrast, the article output for the nations of the former Soviet Union declined at an accelerating rate after the late 1980s, dropping from about 30,000 in 1981 to 22,000 in 1995; this decrease led to a decline in world share from 8 to 5 percent. This long-term decline in world share is not entirely attributable to the disintegration of the Soviet Bloc, although this certainly continues to contribute to the trend. Articles reflect work done one or more years earlier, and the decline has been gradual and observable over the entire period. It is likely that relative political and scientific isolation, combined with economic difficulties, has affected

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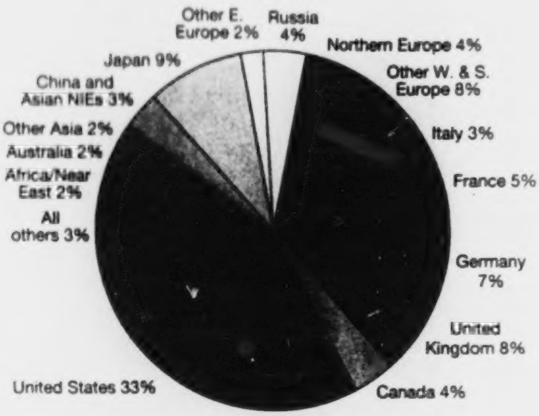
[19] These figures are minimum estimates. While figures from an expanded journal set selected in 1985 are higher, they show roughly the same rate of increase. Data from a journal set selected in 1991 suggest a steeper real rate of increase from 1991 to 1995.

Figure 5-25.
Distribution of articles in world scientific and technical journals, by region/country: 1995



NOTE: NIEs are newly industrialized economies.

See appendix table 5-49. *Science & Engineering Indicators – 1998*

the conduct of scientific research in this region.

Southeast Asia's emergence as a potent, high-tech region is well-known,[60] and data on article production present evidence of a robustly developing indigenous S&E base. The Asian nations' world share of publications rose from 11 to nearly 15 percent since 1981, but contradictory trends combined to produce this total. The number of articles produced by Japan increased from 25,100 in 1981 to 39,500 in 1995; this represents a 57 percent increase, three times the world average. Very large percentage increases over the period—though from very low bases—were evident for China (from 1,100 to 6,200 articles) and the newly industrialized Asian economies: Taiwan (from 370 to 3,900), South Korea (170 to 3,000), Singapore (120 to 900), and Hong Kong (from 500 in 1987[61] to 1,100 in 1995). While these gains were realized on a small output base and the combined output remains modest, the combined world share involved rose from one-half of 1 percent to 3.4 percent in a very short time—with no decrease in growth yet evident. On the other hand, India's publications output has contracted by 33 percent since 1981, dropping from 11,700 articles to 7,900 in 1995.[62]

Since the conduct of research reflected in these article outputs requires financial, physical, and human resources—in short, a scientific infrastructure—the potential for further shifts in article distributions can be gleaned from a brief comparison of the economic and article outputs of selected countries. While no simple relationship exists between the relative size of a nation's GDP and its article output volume,[63] there do appear to be some general tendencies. (See appendix table 5-50.) For the nations shown, the number of papers produced per billion U.S. dollars of GDP ranges from 2 to 54. (See figure 5-26.) Israel and a number of smaller European nations rank highest, exceeding 30 articles per billion U.S. dollars of GDP. The United States is in the middle range, with 20 articles per billion dollars of GDP. Nations with fast-developing economies have smaller than expected article outputs. There is also a large number of nations with economies that are small, or small on a per capita basis, that contribute little to the world's scientific output.

Field Distribution of Articles

As noted earlier, for all countries combined, the life sciences accounted for the bulk (55 percent in 1995) of the articles in the SCI database. (See figure 5-24.) The nearly 20 percent increase in world articles from 1981 to 1995 was driven by increases in physics (63 percent), the earth and space sciences (36 percent), and biomedical research (30 percent). Biology and mathematics publications declined in number (by 11 and 23 percent, respectively), possibly signaling the demise of some journals in these fields. Chemistry and clinical medicine articles increased slightly (by 12 and 16 percent, respectively); while those on engineering and technology did not increase at all. Because of the large number of articles produced each year, shifts in field distribution have been small but noticeable. (See text table 5-12.) For example, the life science share fell by 2 percentage points; those of mathematics and engineering and technology fell by 1 point. Within the life sciences, biology's share fell by 3 points while biomedical research articles increased, suggesting a gradual shift in research focus. The share of physics articles increased by 5 percentage points over the period.

U.S. Article Output in the International Context

The roughly 142,800 U.S. articles published in 1995 accounted for about 33 percent of the world's total, up in number from 132,300 in 1981 but down from the almost 36 percent share of world total these articles then represented. This drop reflects the fact that other nations' publications output has expanded relatively faster than that of the United States. U.S. output has grown in some fields: notably—in round numbers—from about 22,000 to 28,000 in biomedical research, and from 13,000 to 18,000 in physics. It has

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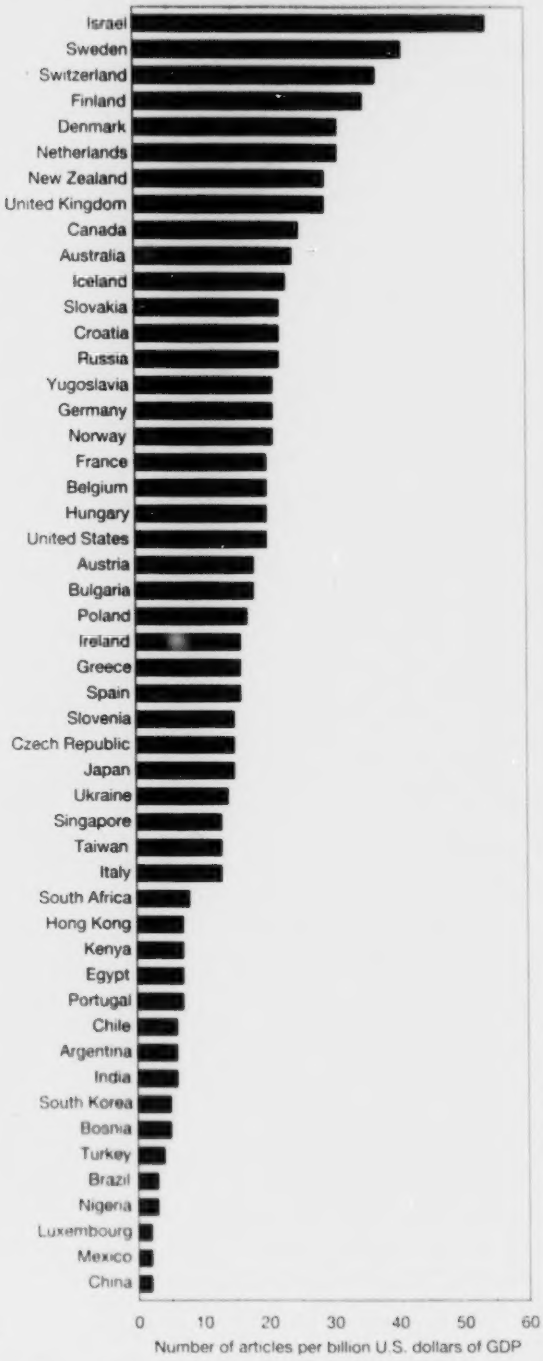
[60] The emergence of these Asian countries in high-tech economic activity is described in NSF (1995a). The expansion of their education activities in science, engineering, and technology is described in NSF (1993a). See also discussions in chapter 2 on higher education developments and chapter 4 on patterns of R&D support.

[61] Hong Kong's data for years before 1987 were reported with the United Kingdom's.

[62] See Raghuram and Madhavi (1996). The authors note that this decline cannot be attributed to journal coverage in SCI, and that it is paralleled by a decline in citations to Indian articles. They speculate that an aging scientific workforce may be implicated, along with a "brain drain" of young Indian scientists whose articles would be counted in the countries in which they are published, not in the author's country of origin.

[63] The simple correlation between GDP share and share of world articles produces an r^2 of 0.75. However, once the United States is removed, the r^2 drops precipitously to 0.29.

Figure 5-26.
Scientific and technical article output of selected countries, per billion U.S. dollars of GDP: 1995



See appendix table 5-50. *Science & Engineering Indicators – 1998*

Text table 5-12.
Share of world scientific and technical articles, by field
(Percentages)

Field	Share of publications 1981	Share of publications 1995	Change, 1981-95
Total life sciences	57.2	55.1	−2.1
Clinical medicine	31.5	30.7	−0.9
Biomedical research	15.0	16.4	1.4
Biology	10.6	8.0	−2.7
Total physical sciences	31.7	36.2	4.4
Chemistry	14.8	14.0	−0.8
Physics	12.3	16.9	4.6
Earth and space sciences	4.6	5.3	0.7
Engineering and technology	8.3	7.0	−1.4
Mathematics	2.8	1.8	−1.0

See appendix table 5-51. *Science & Engineering Indicators – 1998*

been roughly steady in clinical medicine, at about 50,000. Declines in output occurred in biology (from 15,000 to 11,000), engineering and technology (from 12,000 to 10,000), and mathematics (from 4,000 to 3,000). (See appendix table 5-49.)

But the U.S. article portfolio is quite different from that of other major producers (see "The Science and Technology Portfolios of Nations," below); consequently, U.S. world share, and changes in world share, are field dependent. The biggest relative declines occurred in engineering and technology (7 percentage points) and biology (6 points). Smaller declines in the U.S. share (2 to 4 percentage points) occurred in clinical medicine, the earth and space sciences, and mathematics. The physics share contracted by nearly 5 points, while chemistry held steady.

The Science and Technology Portfolios of Nations

Nations make implicit or explicit choices about the nature of their science and technology portfolios through their allocation of resources; the results of these choices are reflected, to some degree, in their article output data. (See appendix table 5-51.) It is clear that different nations have very different choice patterns, and that these patterns can and do—change over time.[64]

Figure 5-27 shows the 1995 portfolio mix of a range of countries, arrayed by the fraction of their total output devoted to clinical medicine and biomedical research (which account for about half of these articles worldwide). The differences in emphasis are striking. The United States, United Kingdom, countries of Northern Europe, several smaller Western European nations, and Chile all emphasize these fields quite heavily. At the other end of the spectrum are China and the rapidly growing newly industrialized Asian economies, India, Eastern Europe, Egypt, and Mexico, each of which has a small fraction of its portfolio in these fields.

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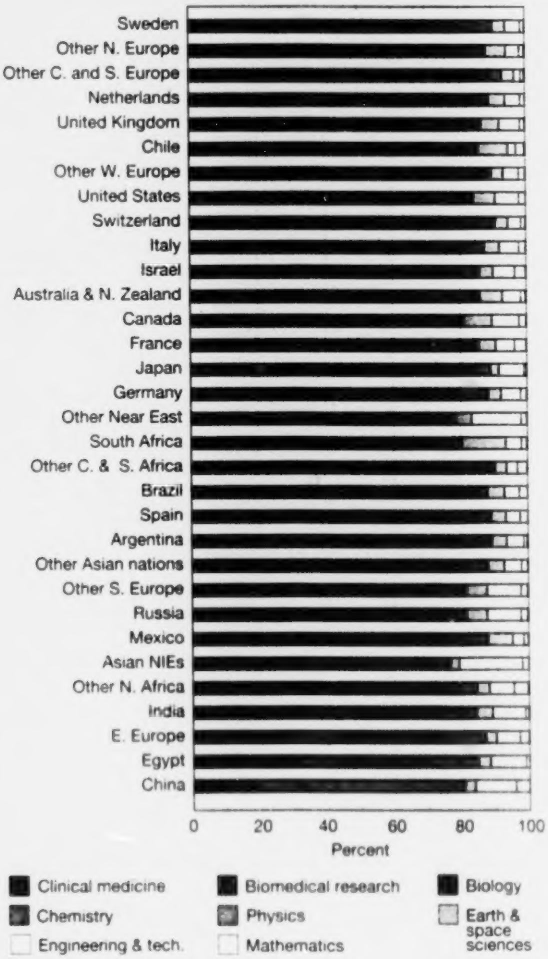
[64] See also the discussion in chapter 2, "Worldwide Increase in S&E Educational Capabilities," on the field distributions of S&E degrees of various nations.

In contrast, France, Germany, Spain, Italy, Eastern European nations, Russia, Mexico, Japan, the newly industrialized Asian economies (especially), India, China, and Egypt put far more weight than the world average on chemistry and physics. Russia, China, Egypt, and—again especially—the Asian economies are noteworthy for their concurrent emphasis on engineering and technology.

Countries tend to shift the focus of their scientific activities gradually over time. (See appendix table 5-51.) Major shifts toward chemistry—and, to a lesser extent, physics—are evident for some of the world's developing nations and regions. Russia, which once had an extremely heavy stake in these traditional fields, is shifting away from them. Biology research is in relative decline around much of the world, in favor of increases in the more applied life science disciplines. Engineering and technology has lost ground in many national portfolios relative to other fields. Note, however, that the portfolios of some of these countries were very small in 1981, making relatively large percentage changes possible as publication counts have grown.

Figure 5-27.
Distribution of selected countries' and regions' scientific and technical articles, by field: 1995



NOTE: NIEs are newly industrialized economies.

See appendix table 5-51. *Science & Engineering Indicators – 1998*

International Scientific Collaboration

In many fields, cutting-edge science is increasingly dependent on knowledge, perspectives, and techniques that cross traditional disciplinary boundaries. Often, the scope of the problem (e.g., constructing a coordinated array of widely spaced telescopes or mapping global environmental trends), combined with complexity and cost, suggests or even dictates broad collaboration that increasingly involves international partners. Both trends—increased collaboration and growing international cooperation—can clearly be seen in the publications data. A pervasive trend toward greater scientific collaboration affects all article fields, and a steadily growing fraction of most nations' papers involves international coauthorship. This section examines these trends, the U.S. position in international collaboration, who collaborates with whom, how developing and developed nations compare, and what collaboration patterns exist for and among Asian nations.[65]

Trends in Scientific Cooperation. A pronounced worldwide tendency exists toward greater scientific collaboration, as evidenced by patterns of corporate coauthorship of scientific and technical articles written by authors located in two or more different institutions.[66] This phenomenon can be observed in every field, every sector, and most countries. Moreover, such collaboration is increasingly international, involving researchers from different nations.[67] In 1995, the proportion of the world's papers that were coauthored (in this multi-institution sense) was 50 percent; almost 30 percent of these involved international collaboration. (See appendix table 5-52.) The number of coauthored articles increased from 121,000 in 1981 (33 percent of the total) to 219,400 in 1995

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[65] The data discussed in this section involve the incidence of article coauthorship in which the authors' institutional affiliations are located in two or more countries. These data have certain limitations. For example, a paper written by a U.S. citizen temporarily residing in the United Kingdom in collaboration with someone at his or her U.S. home institution is counted as internationally coauthored, thus possibly overstating the extent of such collaborations. On the other hand, a paper coauthored by a British citizen temporarily located at a U.S. university with another member of the faculty would not be considered internationally coauthored, thus understating the count. Further, the data suggest a growing trend toward multiple-country coauthorship. However, the trends discussed here are sufficiently broad-based and robust to give confidence in the measure.

[66] This provides a lower bound estimate and understates the true number of papers with multiple authors. The database counts corporate coauthorships that is, two or more authors are counted as coauthors only if they are at two or more institutions. The trends reported here are internally consistent.

[67] Among the causes of these increases are no doubt the extent of advanced training students and recent doctorate-holders receive outside their native countries and the web of intergovernmental agreements inviting or requiring multinational participation in some research activities.

(50 percent). Over this period, the number of internationally coauthored articles worldwide increased by 200 percent—from 21,000 to 63,800—while the total number of articles rose by about one-fifth. This increase in turn caused a rise in the proportion of all papers published worldwide involving some degree of international coauthorship—from 6 percent in 1981 to 15 percent in 1995.

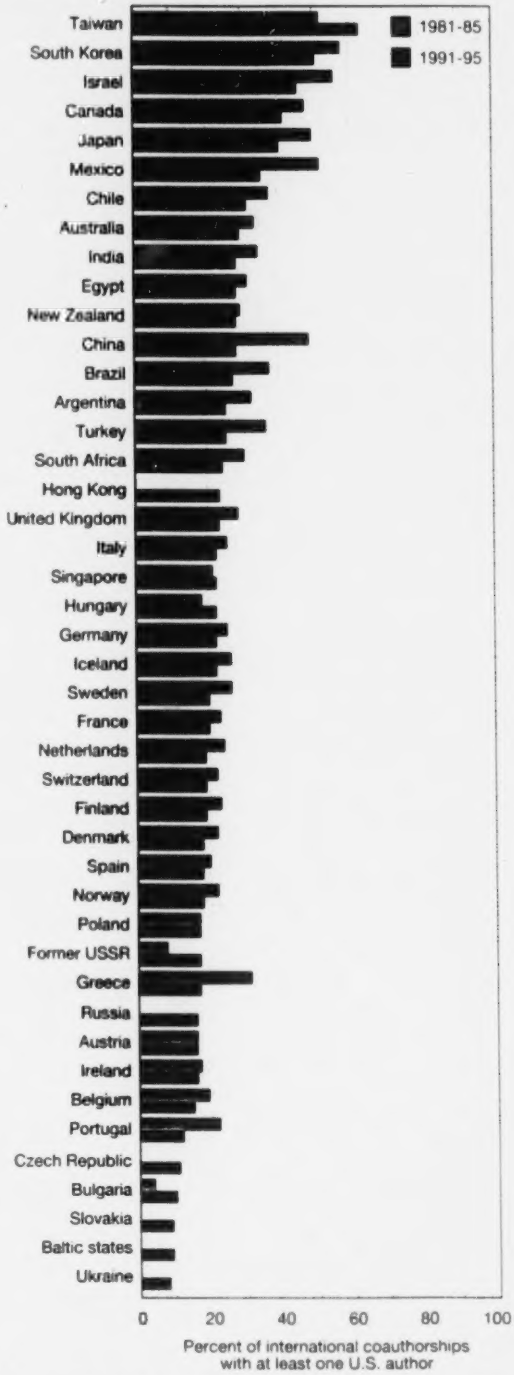
Corporate coauthorship varies by field. For example, in the 1991-95 period, the U.S. average of coauthored articles was 56 percent, but clinical medicine was well above that with 64 percent of its articles coauthored. Chemistry, engineering and technology, biology, and mathematics had lower rates of corporate collaboration, at 39, 43, 46, and 47 percent, respectively; the other fields were close to the mean. (See appendix table 5-53.) Wider variation exists in rates of international collaboration. Measured against all coauthored articles, the U.S. average was 29 percent for 1991-95, but this was heavily influenced by a 19 percent rate of clinical medicine articles. On the other hand, 51 percent of coauthored mathematics articles involved international collaboration, as did 46 percent of physics and 42 percent of earth and space sciences articles.

The position of the United States in international collaboration (as evidenced by coauthorship) is characterized by two complementary trends. For almost every nation with strong international coauthorship ties, the number of articles involving a U.S. author rose strongly between 1981 and 1995. During this period, however, many nations broadened the reach of their international collaborations, causing a gradual diminution of the U.S. share of the world's internationally coauthored articles. (See appendix table 5-54.)

The United States has one of the highest coauthorship rates in the world: 58 percent of U.S. articles published in the ISI journal set involved corporate coauthorship in 1995, up from 43 percent in 1981. U.S. authors contributed 42 percent of all coauthored articles and participated in 45 percent of all internationally coauthored articles—well in excess of the 33 percent U.S. article share. But of all U.S. articles published in 1995, only 18 percent involved international coauthors, a smaller percentage than that of most other nations. These numbers reflect the sheer size of the domestic U.S. science base. Worldwide, domestic and international coauthorships have also risen, often more steeply (in terms of the proportion of a country's papers involved) and to higher levels than in the United States. For most countries, the share of internationally coauthored articles ranges from 25 to 40 percent of their output; but Japan and India (15 percent each), Russia (21 percent), and other former Soviet countries (13 percent) are well below this range. (See appendix table 5-52.)

Who Collaborates With Whom? International scientific collaboration, as measured by the percentage of a country's multi-author articles involving international coauthorship, centers to a considerable degree on the United States. (See figure 5-28.) In the first half of the 1990s, about one in five internationally coauthored papers published in major European industrial nations involved collaboration with the United

Figure 5-28.
Percentage of internationally coauthored articles involving one or more U.S. authors, for selected countries



See appendix table 5-54. *Science & Engineering Indicators – 1998*

States; for many other nations, the rate was much higher. For example, Japan and India, with low rates of international collaboration, shared 40 and 28 percent of their international coauthorships with the United States, respectively; China, 28 percent; Taiwan, 62 percent; and South Korea, 50 percent. (See appendix table 5-54.) Rates of collaboration with the United States ranged from 25 to 35 percent for major South and Central American countries, 45 percent for Israel, and near 30 percent for Australia and New Zealand. Countries of the former Soviet Union collaborated relatively less frequently with U.S. partners, as did all Central European nations except Hungary.

Examination of this same indicator for an earlier period—1981-85—suggests that the scientific world is witnessing the development of new centers of activity, probably reflecting continuing political and economic developments in the wake of the end of the Cold War. Comparison of 1981-85 and 1991-95 data shows strong growth in the number of articles with authors from more than one nation, and—at the same time—a broadening of international collaborative ties. (See appendix table 5-54.) While coauthorship with the United States continued to rise in terms of number of publications, it declined with many countries in terms of the share of all their internationally coauthored articles. (See figure 5-28.) The share drop (but not a decline in the number of articles) in collaboration with the United States was most striking for China—roughly 20 percentage points—but is evident for most other countries as well. A similar pattern, though much attenuated, is evident for the major European industrial nations.

In the Asian region, the trends are somewhat erratic, but generally indicate the development of regional cooperative patterns involving—especially—China and the newly industrialized economies. Regional collaboration, as measured by the proportion of coauthored articles with an author from another Asian country, is almost 25 percent for South Korea, in excess of 30 percent for Singapore and Hong Kong, and around 15 to 20 percent for most other countries; India and Japan have lower rates of coauthorship. The degree of collaboration with Japan has increased for some but not all of these nations, and the absolute number of papers with Japanese coauthors has risen. Collaboration with the United States is high for these economies: Taiwan, 62 percent; South Korea, 50 percent; Japan, 40 percent; China and India, 28 percent each; and the other Asian nations about one-fifth. Collaboration with Europe is less prominent, ranging from 10 to 25 percent for the entire continent.

The Central European states have fairly strong regional collaborative ties, given the relatively small volume of their collective publications output. They share 10 to 15 percent of their internationally coauthored articles. From roughly half to 60 percent of these articles are shared with the rest of Europe—most strongly with Germany (around 20 percent); and the United Kingdom, France, and Italy combined (15 to 20 percent). These figures have increased over their levels in the 1980s, as ties to the countries of the former USSR have generally attenuated in the 1990s. International collaboration involves U.S. scientists in about 10 percent of the cases in Czech Republic, Slovakia, and Bulgaria; in excess of 15 percent for Poland; and over 20 percent for Hungary.

Russia's collaborative ties are mainly with the United States (roughly 15 percent); Germany (15 percent); and the United Kingdom, France, and Italy combined (20 percent). The rest of Europe represents 20 percent; collaboration with other former member states represents 10 percent. As a group, the countries of the former Soviet Union (except the Baltic states) have much the same pattern, though with weaker cooperative links to the United States and Germany, and stronger links to other European nations. Scientists in the Baltic states who collaborate internationally tend to do so with colleagues in the Scandinavian countries (25 percent), attesting to strong cultural and regional ties among these nations.

The U.S. pattern of international coauthorship stands in sharp contrast to those just described (as it must, given the high percentages of U.S. involvement in most other nations' international collaborations). No one country contributes more than 10 percent to the U.S. articles with multinational authors. Canada, the United Kingdom, Germany, all of Southern Europe, the Northern European countries, and all other Western European nations combined contribute between 7 and 10 percent each; the Eastern European and former Soviet states combined contribute another 7 percent; Japan and the other combined Asian nations contribute about 8 percent each. This is a much more even distribution of international collaborative ties than is seen for the other countries.

Countries with small indigenous science establishments tend to have higher levels of international coauthorship as a percentage of their total article output than do those with larger, more mature systems. Rather than collaborating regionally, scientists from developing nations tend to work with those from major science-producing nations. In the case of small but mature nations (e.g., the Northern or smaller Western European countries), this pattern is augmented by regional collaboration. Political isolation, economic disruption (as in the case of the states of the former Soviet Union), and cultural or language barriers (as in the case of Japan) can influence these patterns and result in unusually low degrees of international collaboration.

Use of Scientific and Technical Articles in Subsequent Research

The global dimensions of the conduct of scientific activity, discussed above in terms of international research collaboration, are also reflected in the patterns of citations to the literature. Scientists and engineers around the world cite prior work done elsewhere to a considerable extent, thus demonstrating the usefulness of this output in their own work. Citations to one's own country's work are generally prominent and show less of a time lag than citations to foreign outputs. Regional citation patterns are evident as well, but citations to research outputs from around the world are extensive.

U.S. scientific and technical articles are cited by virtually all mature scientific nations in excess of the U.S. output's world share. (See appendix table 5-55.) This broad finding needs to be qualified, however, since citation patterns and practices vary by field. More specifically, the finding holds for chemistry, physics, biomedical research, and clinical medicine. U.S. articles in the remaining fields tend to be cited at or slightly below their world output share.

Not surprisingly, all countries cite their domestic literature well in excess of their respective world shares, but no other country cites its domestic literature as heavily as does the United States—67 percent. Another 14 percent of U.S. citations are to British, French, German, and Italian articles; 7 percent each to the articles of other European nations and Asia and the Pacific (4 percent for Japan);[68] and 3 percent to Canadian articles.[69] The high U.S. self-citation rate might conceivably reflect insularity, but the high proportion of involvement of U.S. scientists in internationally coauthored articles casts doubt on this interpretation.

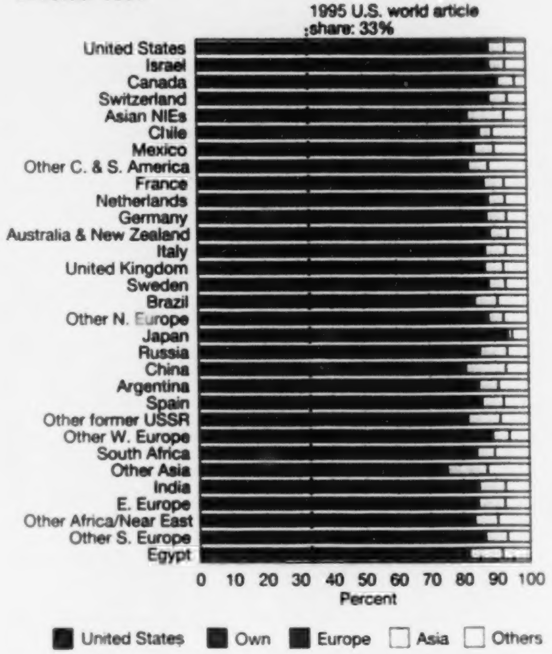
A comparison of citations to the U.S. literature (the leftmost column of appendix table 5-55) with those to a nation's domestic output (diagonal values) shows a generally larger share of total citations to U.S. than to domestic articles. (See figure 5-29.) In part, of course, this reflects the scale and breadth of the U.S. scientific and technical establishment. Yet there is no compelling reason why one country's literature should be cited in proportion to its world output share by any other country. For example, no European country cites another European country's output at the rate of the cited country's article share, despite the many arrangements that foster collaboration and knowledge flows among the European nations. It appears reasonable to conclude that scientists elsewhere find the outputs from U.S. research quite useful in the conduct of their own work, as evidenced by the volume of references to the U.S. literature in other countries' scientific and technical articles.

The citations in articles from the four largest European industrial nations—the United Kingdom, France, Germany, and Italy—refer to their respective domestic outputs 21 to 30 percent of the time, to articles of the other countries in the set 11 to 18 percent of the time, and to U.S. articles between 36 and 38 percent of the time. Output from the rest of Europe receives 10 to 12 percent of citations; Canada, 3 percent; and Asia and the Pacific, 7 percent (4 to 5 percent to Japanese articles).

The citations from other Western, Southern, and Northern European nations refer to their own domestic literature 10 to 23 percent of the time—reflecting their generally smaller domestic science base—and the four large European industrial nations 18 to 28 percent. The United States receives 32 to 42 percent of the citations; and other European nations combined, 10 to 17 percent. Asia and the Pacific receive 7 to 9 percent of these nations' citations.

The pattern of citations among Central European nations is similar, with a regional component of 3 percent, and an additional 1 to 3 percent referring to the literature of the former Soviet states. A stronger orientation than for most other countries is evident toward Asia and the Pacific, which receive a combined 9 to 11 percent of the citations.

Figure 5-29.
Citations in selected countries' scientific and technical literature to U.S., own, and major regions' articles: 1995



NOTES: "Own" means countries' citations to their own literature; for regional groupings, to the literature of that group of countries. NIEs are newly industrialized economies.

See appendix table 5-55. *Science & Engineering Indicators – 1998*

Somewhat less reliance on European science output, somewhat greater reliance on that of the United States, and more of a regional Asian/Pacific focus mark the citation ties of the Asian nations. China and the newly industrialized economies cite their own articles only 10 to 20 percent of the time, but cite each others' articles 12 to 16 percent of the time—high relative to the size of their science bases. Japan's pattern is different (37 percent self-citation and only 2 percent of citations to articles from other states in the region); as is India's (29 percent self-citation, 6 percent citation to Japan's output, and 2 percent to the rest of the region).

Patent Outputs

Governments assign property rights to inventors in the form of patents to foster inventive activity that may have important economic benefits. The U.S. Patent and Trademark Office grants such government-sanctioned property rights in the form of patents for inventions deemed to be new, useful, and nonobvious. This section discusses recent evidence about strengthening ties between scientific and technical research and patenting activity, trends in academic patenting, and income from these activities flowing to universities and colleges.[70]

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[68] Asia and the Pacific includes Australia and New Zealand.

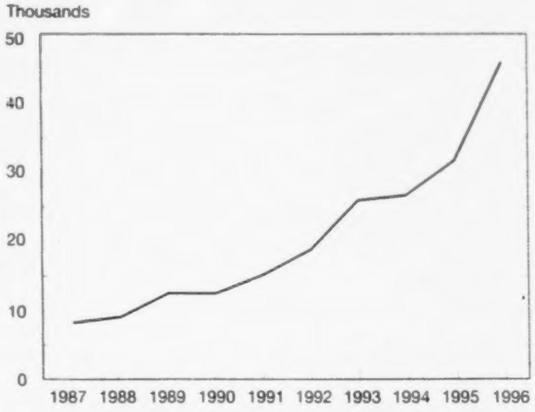
[69] Percentages do not total 100 because of rounding.

Citations in U.S. Patents to the Scientific and Technical Literature

Patent applications cite "prior art," including scientific and technical articles, that contributes materially to the product or process to be patented and upon which it improves. These citations provide some indication of the potential contributions of published research results to patentable U.S. inventions. A number of caveats apply. The use of patenting varies by industry segment, and many citations on patent applications are to prior patents. Industrial patenting is only one way of seeking to ensure firms' ability to appropriate returns to innovation and thus reflects, in part, strategic and tactical decisions. Such patenting can be defensive or forward-looking, or can lay the groundwork for cross-licensing arrangements. Most patents do not cover specific marketable products but might conceivably contribute in some fashion to one or more such products in the future. These caveats notwithstanding, citations to the scientific and technical literature give one indication of the linkage between research outputs and innovative applications, as judged by the patent applicant.

The scientific and technical literature is increasingly likely to be cited on U.S. patents. The percentage of U.S. patents citing at least one scientific or technical article increased from 11 percent in 1985 to 14 percent in 1990 and 23 percent in 1995.[71] To further explore this trend, citations to U.S. research articles included in the SCI set of journals were identified and classified by field and performer sector for all U.S. patents issued from 1987 through 1996. The number of such citations increased from 8,600 in 1987 to 47,000 in 1996[72] (see figure 5-30 and text table 5-13), and their field distribution shifted dramatically toward the life sciences. The rise in the number of citations held for all fields and for papers from all sectors. (See appendix table 5-56.) The fastest growth, however, occurred in the life sciences. The biomedical research share rose from 28 to 44 percent, and that of clinical medicine rose from 26 to 29 percent. The combined share of physics, chemistry, and engineering and technology citations dropped from 43 to 24 percent of these patent citations—but not their absolute number, which rose from 4,018 in 1988 to 11,246 in 1995.

Figure 5-30.
Number of citations on U.S. patents to U.S. scientific and technical articles



NOTE: The recent increase may partly reflect changed processing of patent applications by the U.S. Patent and Trademark Office, the ease of locating scientific and technical articles, and greater incentive to cite them.

See appendix table 5-56. *Science & Engineering Indicators – 1998*

Citations to academic articles rose faster than to those from industry or government authors, pushing the academic share of the total from 49 to 55 percent. The increase was driven by strong gains in chemistry (where the academic share rose from 58 percent in 1988 to 65 percent in 1995), physics (from 29 to 40 percent), and engineering and technology (from 31 to 44 percent).

A recent study examined all citations on the front page of all 397,660 U.S. patents awarded in 1987-88 and 1993-94 (Narin, Hamilton, and Olivastro 1997). Many of these citations are to other patents, but among all citations, 430,226 referred to nonpatent materials; of these, 242,000 were judged to be science references, of which 175,000 were to materials in SCI journals. Among the study's findings are a rapid increase in the number of citations to scientific and technical articles on U.S. patent applications; a shortening of the time elapsed between publication and citation on patents; and a large proportion of such citations to publicly funded science (defined by the authors to include articles by academic, nonprofit, and government authors).[73] References tended to be to articles appearing in nationally and internationally recognized, peer-reviewed journals, including journals publishing basic research results, and to be field- and technology-specific.[74] The authors note both national (U.S. patents citing U.S. authors with greater than expected frequency) and regional components in the patterns of citations.

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[70] Chapter 6 presents a more comprehensive discussion of patented inventions in all U.S. sectors.

[71] Personal communication with Francis Narin and Kim Stevens, CHI Research, Inc.

[72] The U.S. Patent and Trademark Office changed its processing of patent applications during this period, and some of the observed increase probably reflects these changed practices and applicants' responses to them. Furthermore, greater ease of locating—electronically—the relevant prior art, and greater incentives to include all possible elements thereof, may also contribute to the increase. Nevertheless, the direction of the trends reported here is congruent with those in academic patenting, discussed below. The number of citations reported here refers to articles published in an 11-year span, as follows: 1987 patent citations are to articles published in 1973 to 1984, 1995 citations to those published in 1981 to 1992.

[73] This latter finding is broadly consistent with results obtained by Mansfield (1991), focusing on academic science only and using a very different study framework and approach.

[74] See tables 2 and 3 in Narin, Hamilton, and Olivastro (1997).

Text table 5-13.
Number and distribution of citations on U.S. patents to the U.S. scientific and technical literature, by field

Patent issue year	Total	Clinical medicine	Biomedical research	Biology	Chemistry	Physics	Earth & space sciences	Engineering & technology	Mathematics
					Number of citations				
1987	8,597	2,221	2,391	168	1,181	1,286	104	1,244	0
1988	9,495	2,423	2,749	220	1,212	1,595	81	1,211	2
1989	12,950	3,193	3,978	304	1,536	2,356	117	1,461	2
1990	12,906	3,417	3,818	306	1,673	2,169	76	1,443	3
1991	15,718	4,208	5,199	437	1,921	2,424	123	1,401	2
1992	19,404	5,294	6,949	436	2,451	2,667	92	1,494	18
1993	26,694	7,393	10,736	547	3,027	3,024	93	1,850	21
1994	27,422	7,223	10,334	675	3,114	3,589	121	2,349	14
1995	32,500	9,171	12,713	812	3,689	3,366	134	2,593	19
1996	47,059	13,630	20,617	1,344	4,533	3,498	193	3,215	25
					Percentage of citations				
1987	100	26	28	2	14	15	1	14	0
1988	100	26	29	2	13	17	1	13	0
1989	100	25	31	2	12	18	1	11	0
1990	100	26	30	2	13	17	1	11	0
1991	100	27	33	3	12	15	1	9	0
1992	100	27	36	2	13	14	0	8	0
1993	100	28	40	2	11	11	0	7	0
1994	100	26	38	2	11	13	0	9	0
1995	100	28	39	2	11	10	0	8	0
1996	100	29	44	3	10	7	0	7	0

NOTE: Count for 1987 patents is of citations to articles published in 1973-84; for 1988 patents to articles published in 1974-85, etc.

See appendix table 5-56.

Science & Engineering Indicators – 1998

Patents Awarded to U.S. Universities

Patents may be awarded on the results of academic R&D deemed to have potential utility for the development of new or improved products or processes. While the bulk of academic R&D is basic research (i.e., research that is not undertaken to yield or contribute to immediate practical applications), data on the patenting activities of universities and colleges suggest that academic institutions are giving increased attention to the potential economic benefits that may be inherent in their R&D results. A growing number of universities and colleges are applying for, and receiving, protection for results of work conducted under their auspices, even though the returns on such patents remain low, on average, when measured against their R&D expenditures. (See "Income From Patenting and Licensing Arrangements," below.) The number of patents and institutions involved is small when viewed against the backdrop of all U.S. patenting activity, but the increases are of interest.

After slow growth in the 1970s, the number of academic institutions receiving patents increased rapidly in the 1980s from about 73 early in the decade to more than double that by 1989 and 168 by the mid-1990s.[75] This development, pronounced during the 1980s and more muted in this decade, affected the number of both public and private institutions receiving patent awards. (See figure 5-31.) Starting in the early 1980s, the number of institutions outside the ranks of the largest research universities (defined here as the top 100 in total 1995 R&D expenditures) with patent awards increased at a rapid pace. While the largest research universities had constituted 70 percent of all academic institutions receiving patents in 1982, their share of all academic institutions had fallen to just half in 1995—signaling a broadening of the institutional base, especially among public universities and colleges. (See appendix table 5-57.) Nevertheless, by 1995, 86 of the top 100 universities in total R&D expenditures received one or more patents.[76]

This expansion of the number of institutions receiving patents coincided with rapid growth in the number of patent awards: this latter rose from 458 in 1982 to 1,860 in 1995. Public institutions expanded their patenting activity somewhat more rapidly than did their private counterparts: the former received 64 percent of newly issued academic patents in 1995, up from 53 percent in 1982. At the same time, the top 100 R&D-performing institutions increased their share of the expanding academic patent base from about three-quarters to over 80 percent of the total, where it has leveled off. (See appendix table 5-57.)

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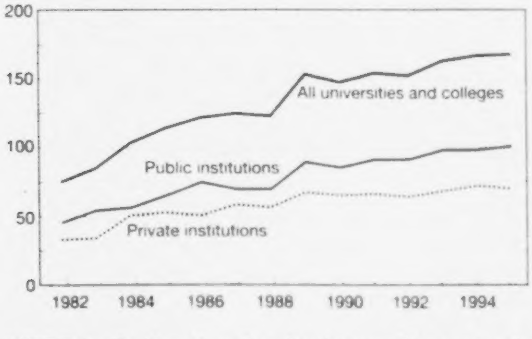
[75] No exact count or correlation with research dollars spent is possible, since patent ownership patterns depend on individual university or university system practices, which vary across institutions and over time. Patents may be assigned to boards of regents, individual campuses, subcampus organizations, separately created entities affiliated with one or more universities, or entities without any university affiliation. This discussion is based on data aggregated in consistent fashion to individual institutions or university systems, as the case may be, starting in the 1980s.

[76] This is a minimum estimate, since patent awards to some universities—e.g., University of California campuses—are generally recorded at the system level.

The number of academic patents rose more than sevenfold in just over two decades, from about 250 annually in the early 1970s to more than 1,800 in 1995. (See figure 5-32.) This is a far more rapid increase than for all annual U.S. patent awards, which roughly doubled over the period. As a result, academic patents now constitute about 3 percent of all new awards, up from less than one-half of 1 percent two decades ago. A change in U.S. patent law may have contributed to the strong rise in the 1980s; the law now allows academic institutions and small businesses to retain title to inventions resulting from federally supported R&D. Other contributing factors may be the creation of specialized university technology transfer and patenting units, an increased focus on commercially relevant technologies, and closer ties between scientific and engineering research and technological development (see Henderson, Jaffe, and Trajtenberg 1995).

Patents are assigned to utility classes according to their likely areas of application. The distribution of all patents over these areas has evolved slowly, but for academic patents, two pronounced changes have taken place. The growth in the number of academic patents was accompanied by a decrease in the number of utility classes in which they fall. In addition, academic patents are more heavily concentrated in relatively few application areas than are all U.S. patents. This is not surprising, since many patents in many application areas are not science-based at all. Nevertheless, the concentration is remarkable. Over the entire period covered by the database, 1969-95, utility classes in which universities were at least twice as likely as others to be awarded patents accounted for 12 percent of all patents, but half of all academic patents. (See appendix table 5-58.) A heavy concentration is evident in areas connected with the life sciences, along with some areas of physics and chemistry. (See appendix table 5-59.) In fact, the fraction of academic patents in just three utility classes—all with presumed biomedical relevance[illegible]—jumped from 8 percent of the total in the early 1970s to more than a quarter in the mid-1990s. (See figure 5-33.)

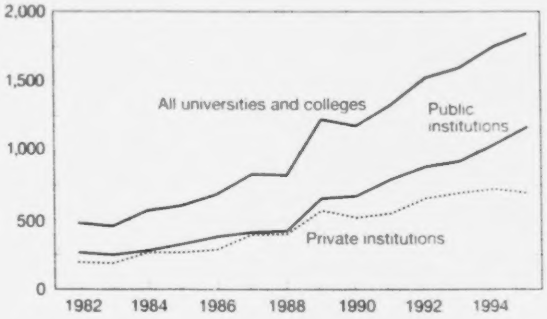
Figure 5-31.
Number of universities and colleges granted patents



NOTE: Data reflect lower bound numbers because of some university systemwide reporting.

See appendix table 5-57. *Science & Engineering Indicators – 1998*

Figure 5-32.
Number of academic patents granted



See appendix table 5-57. *Science & Engineering Indicators – 1998*

Income From Patenting and Licensing Arrangements

Valuation of patents—especially of science-based ones—is difficult. Actual use is uncertain, there is generally no direct connection between an individual patent and an economically valuable product or process, and acquisition of licensing rights may be motivated by protection rather than by intent to use. Nevertheless, universities increasingly are negotiating royalty and licensing arrangements based on their patents. While total reported revenue flows from such licensing arrangements remain low, a strong upward trend points to the confluence of two developments: a growing eagerness of universities to exploit the economic potential of research activities conducted under their auspices, and readiness of entrepreneurs and companies to recognize and invest in the market potential of this research.

A 1992 survey by the U.S. General Accounting Office based on 35 universities found that they had substantially expanded their technology transfer programs during the 1980s. Typical licensees were small U.S. pharmaceutical, biotechnology, and medical businesses. During 1989-90, the reported income flows based on these licenses were modest: a mere $82 million. A more extensive survey conducted periodically since 1991 (AUTM 1996) reported gross revenue receipts of $299 million in 1995, compared with $130 million in 1991. (See text table 5-14.) The survey—while extensive—is not nationally representative; thus, these estimates must be seen as lower bound numbers. Moreover, a portion of these reported revenue increases reflects expanded coverage.

[illegible] Utility classes number 424 and 514 capture different aspects of "Drug, bio-affecting and body treating compositions"; utility class number 435 is "Chemistry: molecular biology and microbiology."

Text table 5-14.
Overview of academic patenting and licensing activities

	1991	1992	1993	1994	1995
Gross royalties (million $)	130	172.4	242.3	265.9	299.1
New research funding from license (million $)	NA	NA	NA	106.3	112.5
Invention disclosures received	4,880	5,700	6,598	6,697	7,427
New patent applications filed	1,335	1,608	1,993	2,015	2,373
Total patents received	NA	NA	1,307	1,596	1,550
Startup companies formed			916[a]	175	169
Number of revenue-generating licenses, options	2,210	2,809	3,413	3,560	4,272
New licenses and options executed	1,079	1,461	1,737	2,049	2,142
Equity licenses and options				464[b]	99
Royalties paid to others (million $)	NA	NA	19.5	20.8	25.6
Unreimbursed legal fees expended (million $)	19.3	22.2	27.8	27.7	34.4
Sponsored research (billion $)	11.5	12.8	14.9	16.1	17.2
Industry-funded research	0.9	1.0	1.2	1.4	1.4
Federally funded research	8.1	9.1	10.1	10.7	11.4
Number of institutions responding	90	93	115	120	127

NA = not available

[a] Startup companies reported to have been formed through 1993.

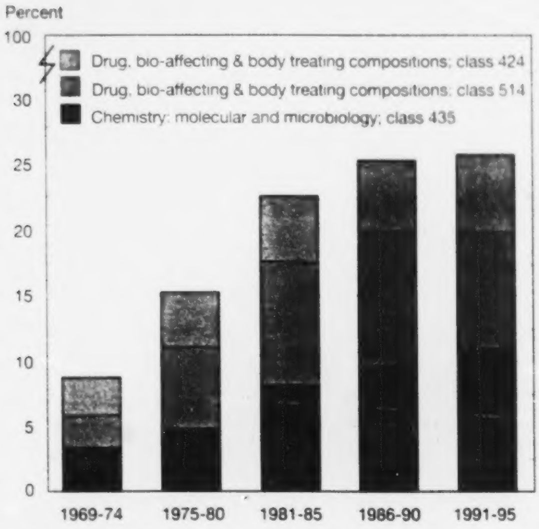
[b] Equity licenses and options granted through 1994.

NOTES: Figures on patenting differ from those reported for all universities and colleges by the U.S. Patent and Trademark Office since they do not reflect the activities of all U.S. universities and colleges. Data are internally consistent for each year shown but cannot be treated as trend data because of the growing number of institutions participating in the survey and varying nonparticipation of major research universities.

SOURCE: Association of University Technology Managers, Inc., AUTM Licensing Survey, Fiscal Year 1991-Fiscal Year 1995.

Science & Engineering Indicators – 1998

Figure 5-33.
Percentage of total academic patents in three utility classes



See appendix table 5-59. *Science & Engineering Indicators – 1998*

Conclusion

Academic R&D and S&E educational activities have long been a significant part of the U.S. R&D enterprise. R&D spending by universities and colleges is projected to reach $23.8 billion in 1997, accounting for an estimated 12 percent of total national R&D expenditures. The academic sector also continues to be the single largest performer of basic research, accounting for an estimated 52 percent of national basic research expenditures. The bulk of funding for academic R&D is provided by the Federal Government (60 percent in 1997); the second largest funding source is higher education institutions themselves (19 percent). State and local governments contribute 8 percent of the total, and industry and all other sources combined account for about 7 percent each. The bulk of federal funding is provided by three agencies: the National Institutes of Health with 57 percent, the National Science Foundation with 15 percent, and the Department of Defense with 10 percent.

Extensive physical infrastructure exists in support of academic R&D. About $3.1 billion in expenditures for constructing new *research facilities* were planned for 1996-97, along with another $1.3 billion for repair and renovation. Since 1988 (when comparable data first became available), academic S&E research space has increased by 22 percent, to 136 million net assignable square feet. New construction projects initiated between 1986 and 1995 which will either replace existing or add new space are expected to produce over 52 million square feet of research space by the time they are completed. In 1996, deferred construction or renovation projects totaled $9.3 billion, of which $7.4 billion was carried on approved construction plans. The major facilities funding sources are state governments (38 percent) and the institutions themselves (23 percent). Expenditures for *research equipment* were running just below 6 percent of total 1995 R&D expenditures. The major funder of research equipment remains the Federal Government (59 percent in 1995). In 1996, academic institutions rated 37 percent of their research laboratory space as suitable for the most scientifically competitive research; 44 percent as possibly needing some repair or renovation but effective for most levels of research; and 19 percent as needing major repair, renovation, or replacement. Overall, 27 percent of in-use research instruments were judged to be state of the art, another 63 percent as adequate for researcher needs, and 9 percent as inadequate.

About half of the nation's doctoral S&E research workforce was located in academic institutions—roughly 153,500 in 1995, including postdoctorates. The number of academic doctoral scientists and engineers reporting research as their primary work responsibility continued to grow, reaching 83,000 in 1995. Much of the growth, especially since the mid-1980s, occurred outside the traditional research universities: the number of institutions in this segment with federal R&D support reached 654 in 1995, up from 335 in 1975. In the course of their work, academic researchers are supported by, and help train, about 330,000 full-time S&E graduate students. For about 90,000 of them, a research assistantship was their most important means of support in 1995. The Federal Government is the primary source of support for about half of these students. In fact, RAs have grown in importance. The proportion of graduate students with research assistantships as their primary means of support increased from 22 to 27 percent between 1980 and 1995. A larger percentage of graduate students in the physical sciences, the environmental sciences, and engineering rely on RAs as their primary mechanism of support than do students in other disciplines.

Academic researchers produced 71 percent of all U.S.-authored scientific and technical articles in an international core set of peer-reviewed natural science and engineering journals included in the Institute for Scientific Information's Science Citation Index, and 23 percent of the world output published in these journals. (The total U.S. article share in 1995 was 33 percent.) Academic scientists and engineers increasingly collaborate with colleagues elsewhere: in 1995, nearly a quarter of all academic articles involved one or more authors from another U.S. employment sector.

Academic research, though predominantly basic, is increasingly connected with potential practical applications. More than 1,800 patents were awarded to academic institutions in 1995, which represented over 3 percent of all U.S. patent grants in that year. Academic patents were concentrated in a smaller set of application areas than patents of other awardees, with significant strengths in the life sciences, physics, and chemistry. In fact, more than a quarter of all academic patents fell into only three application areas with presumed biomedical relevance. Income from patenting and licensing agreements continued to grow and reached $299 million in 1995. And the number of citations to scientific and technical articles on patent applications, which has risen strongly in recent years, exceeded 47,000 in 1996—roughly 26,000 of which were to academic articles.

The increasingly global nature of the scientific and engineering enterprise is reflected in an ubiquitous increase in the number of articles that have authors from more than one country. Roughly half of the 439,000 articles published worldwide in the SCI journal set referred to earlier had authors from multiple institutions, and nearly 30 percent of these multi-author papers involved international collaboration. Two complementary trends characterize the U.S. position. For almost every nation with strong international coauthorship ties, the number of papers involving U.S. researchers rose strongly over the past decade and a half. But during this period, many nations broadened the reach of their international collaborations, leading to a gradual diminution of the U.S. share of articles involving international collaborations.

Citations to scientific and technical articles offer an indication of the perceived utility of the results of previous work in subsequent research. In a given country's literature, citations to local work tend to figure prominently and have less of a time lag than citations to work published abroad. But U.S. authors tend to be cited by scientists in virtually all mature scientific nations in excess of the U.S. world share of articles in chemistry, physics, biomedical research, and clinical medicine; U.S. articles in the remaining fields tend to be cited at or slightly below the U.S. share. But no other country cites the domestic literature as heavily as the United States—67 percent in 1995—probably reflecting, at least in part, the sheer scale of the nation's scientific and technical enterprise.

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Chapter 6
Industry, Technology, and Competitiveness in the Marketplace

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Highlights

INTERNATIONAL ECONOMIC COMPARISONS

- **The U.S. economy continues to rank as the world's largest, and Americans continue to enjoy one of the world's higher standards of living.** Japan's economy was less than 18 percent of the U.S. economy in 1960 and trailed several European economies. By 1970, it had grown to be the world's second largest economy, and in 1989, Japan had a gross domestic product (GDP) almost twice that of Germany and equal to nearly 40 percent of U.S. GDP.

- **Comparisons of general levels of labor productivity, measured by GDP per employed person, again show that other parts of the world are quickly closing in on the U.S. lead position.** For over 40 years, labor productivity growth in the United States generally trailed that in other countries. In 1960, U.S. GDP per employed person was twice that calculated for most European nations and four times that calculated for Japan. As of 1995, the gap has closed significantly, with labor productivity rates in many European nations nearly equal to that achieved in the United States. Productivity growth in Japan appears to have slowed down some since the early 1990s.

U.S. TECHNOLOGY IN THE MARKETPLACE

- **The United States continues to be the leading producer of high-tech products, responsible for about one-third of the world's production.** While its margin of leadership narrowed during the 1980s when Japan rapidly enhanced its stature in high-tech fields, by 1995 U.S. high-tech industries regained world market share lost during the previous decade.

- **The market competitiveness of individual U.S. high-tech industries varies, although each of the industries maintained strong—if not commanding—market positions over the 15-year period examined.** Three of the four science-based industries that form the high-tech group (computers, pharmaceuticals, and communications equipment) gained market share in the 1990s. The aircraft industry was the only U.S. high-tech industry to lose market share from 1990 to 1995.

- **U.S. trade in technology products accounts for a much larger share of U.S. exports than U.S. imports; it therefore makes a positive contribution to the U.S. overall balance of trade.** After several years in which the surplus generated by trade in technology products declined, preliminary data for 1996 show a larger surplus than in 1995. Between 1990 and 1995, the U.S. trade surplus in software technology doubled. During that same period, trade in aerospace technologies consistently produced large—albeit declining—trade surpluses for the United States.

- **The United States is also a net exporter of technological know-how sold as intellectual property.** Royalties and fees received from foreign firms have been, on average, three times those paid out to foreigners by U.S. firms for access to their technology. U.S. receipts from licensing of technological know-how to foreigners exceeded $3.3 billion in 1995, up from $3.0 billion in 1994. Japan is the largest consumer of U.S. technology sold as intellectual property; South Korea is the second largest customer.

INTERNATIONAL TRENDS IN INDUSTRIAL R&D

- **Despite a two-decade decline in its international share of industrial research and development (R&D), the United States remains the world's leading performer of industrial R&D by a wide margin.** After 1990, the U.S. share stabilized at 46 percent of total industrial R&D performed by Organisation for Economic Co-operation and Development (OECD) countries. By comparison, the European Union accounted for 30 percent of the total industrial R&D performed by OECD countries during 1990-94; Japan accounted for about 20 percent. Preliminary 1995 data indicate a 1 percentage point rise in U.S. share, a 1 percentage point decline for Japan, and no change for the European Union.

- **The latest internationally comparable data on industry-level U.S. industrial R&D performance show the service sector's share rising from 4 percent in 1982 to 24 percent by 1992.** U.S. service sector industries, such as those developing computer software and providing communication services, have led the increase in R&D performance within the U.S. service sector. In 1994, this sector's share of total dropped to around 20 percent. Nevertheless, it still accounts for a larger share of U.S. industrial R&D performance than either the aerospace industry (11.9 percent of total) or the automobile industry (11.2 percent)—the top two R&D-performing industries in the U.S. manufacturing sector in 1994.

PATENTED INVENTIONS

- **In 1994, for the first time ever, more than 100,000 patents were issued in the United States.** This record number of new patented inventions caps off what had been several years of steady increases that began in 1991. In 1995, the number of new U.S. patents granted again topped 100,000, with the final count reaching 101,419. U.S. inventors received 55 percent of the patents granted in 1995; this continues a general upward trend in the proportion of new patents granted to U.S. inventors that began in the late 1980s.

- **Foreign patenting in the United States continues to be highly concentrated by country of origin.** In 1995, two countries—Japan and Germany—accounted for over 60 percent of foreign-origin U.S. patents. The top five countries—Japan, Germany, France, the United Kingdom, and Canada—accounted for 80 percent. Several of the newly industrialized economies, notably Taiwan and South Korea, have dramatically increased their patent activity since the late 1980s.

- **Recent patent emphases by foreign inventors in the United States show widespread international focus on several commercially important technologies.** Japanese inventors tend to concentrate their U.S. patenting in consumer electronics, photography, photocopying, and—more recently—computer technologies. German inventors continue to develop new products and processes in technology areas associated with heavy manufacturing industries. Inventors from Taiwan and South Korea are earning an increasing number of U.S. patents in communications and computer technologies.

- **Americans successfully patent their inventions around the world.** U.S. inventors received more patents than other foreign inventors in neighboring countries (Canada and Mexico) and in distant markets such as Japan, Hong Kong, Brazil, India, Malaysia, and Thailand.

- **International patenting in three important technologies—robot technology, genetic engineering, and advanced ceramics—underscores the inventive activity by the United States, Japan, and Europe.** Based on an examination of national patenting in 33 countries during the 1990-94 period, Japan and the United States lead in overall technological activity in these areas. Although South Korea's share of international patent families was lowest overall for the countries examined, it made an impressive showing in each of the technology areas.

VENTURE CAPITAL AND HIGH-TECHNOLOGY ENTERPRISE

- **The pool of venture capital managed by U.S. venture capital firms grew dramatically during the 1980s as venture capital emerged as an important source of financing for small innovative firms.** In the 1990s, the venture capital industry experienced a "recession" of sorts as investor interest waned and the amount of venture capital disbursed declined. But this slowdown was short-lived: investor interest picked up in 1992, and disbursements began to rise again.

- **Software companies attracted more venture capital than any other technology area.** In 1995, venture capital firms disbursed a total of $3.9 billion, of which 20 percent went to firms developing computer software or providing software services. Medical and health-related companies were second with 14 percent.

- **Very little venture capital actually goes to the struggling inventor or entrepreneur as "seed" money.** Over the past 10 years, money given to prove a concept or for early product development never accounted for more than 7 percent of total venture capital disbursements and most often represented 3 to 4 percent of the annual totals. In 1995, seed money accounted for 6 percent of all venture capital disbursements, while money for company expansion garnered 42 percent.

- **As in the United States, venture capitalists in Europe are attracted to young, small, fast-growing companies in need of capital and management expertise.** Europe now has venture-capital-backed investments all across the continent, including investments in many of the transitioning countries in Central and Eastern Europe.

- **While computer-related and biotechnology companies in the United States garner the lion's share of U.S. venture capital, the types of firms attracting venture capital in Europe are less technology intensive.** Europe has long held a reputation for excellence in industrial machinery and equipment, fashion, and leisure products (e.g., sporting goods). These same industries are among the top recipients of European venture capital.

- **European venture capitalists, like their American counterparts, direct only a small portion of capital disbursements as seed money or startup capital.** Investments for expanding an existing company's productive capacity, helping a company add a new product line, or enabling a company to acquire an existing business—later stage investments—account for about 85 percent of European venture capital disbursements.

NEW HIGH-TECH EXPORTERS

- **Several Asian economies seem headed toward future prominence as technology developers and a greater presence in global high-tech product markets,** when a model of leading indicators is applied. Taiwan and South Korea seem best positioned to enhance their stature in technology-related fields and their competitiveness in high-tech markets. Malaysia and the Philippines scored surprisingly well in many areas and could be the next Asian "tigers," although the model suggests that their technological foundations are still less developed and narrower than those found in either Taiwan or South Korea. Recently, several Asian nations have faced turmoil in their banking systems and capital markets. It is unclear how these developments will affect Asian economies and their science and technology capabilities.

Introduction

Chapter Background

A nation's competitiveness is often judged by its ability to produce goods that find demand in the international marketplace while simultaneously maintaining—if not improving—the standard of living of its citizens (OECD 1996). Science and engineering (S&E), and the technological developments that emerge from S&E activities, enable high-wage nations like the United States to compete alongside low-wage countries in today's increasingly global marketplace. Although the U.S. economy continues to rank as the world's largest, and Americans continue to enjoy one of the world's higher standards of living, many other parts of the world are closing the gap. (See figure 6-1 and appendix tables 6-1, 6-2, and 6-3.)

This chapter highlights the unique role played by industry within the nation's science and technology (S&T) enterprise as it develops, uses, and commercializes investments in S&T made by industry, academia, and government. Within the chapter, indicators or proxies identify trends that provide measurements of industry's part in the nation's S&T enterprise and, wherever possible, place U.S. activity and standing in the more science-based industries in a global context.

Chapter Organization

This chapter begins with a review of the market competitiveness of industries that rely heavily on research and development (R&D); these are often referred to as high-technology industries.[1] The importance of high-tech industries is linked to their high R&D spending and performance which produce innovations that spill over into other economic sectors; additionally, these industries help train new scientists, engineers, and other technical personnel (see Nadiri 1993 and Tyson 1992). The market competitiveness of a nation's technological advances, as embodied in new products and processes associated with these industries, can also serve as an indicator of the effectiveness of that country's S&T enterprise. The marketplace provides a relevant economic evaluation of a country's use of science and technology.

U.S. high-tech industry competitiveness is assessed through an examination of market share trends worldwide, at home, and in various regions of the world. New data on royalties and fees generated from U.S. imports and exports of technological know-how are used to gauge U.S. competitiveness when technological know-how is sold or rented as intangible (intellectual) property.

The chapter explores several leading indicators of technology development (1) via an examination of changing emphases in industrial R&D among the major industrialized countries and (2) through an extensive analysis of patenting trends. New information on international patenting trends of U.S. foreign inventors in several important technologies is presented.

The chapter also presents information on trends in venture capital disbursements. Venture capital is an important source of funds used in the formation and expansion of small high-tech companies. This section examines venture capital disbursements by stage of financing and by technology area in the United States and in Europe.

The chapter concludes with a presentation of leading indicators that are designed to identify those developing and transitioning countries with the potential to become more important exporters of high-technology products over the next 15 years.

U.S. Technology in the Marketplace

Most countries in the world acknowledge a symbiotic relationship between national investments in S&T and competitiveness in the marketplace: science and technology support business competitiveness in international trade, and commercial success in the global marketplace provides the resources needed to support new science and technology. Consequently, the health of the nation's economy becomes a performance measure for the national investment in R&D and in science and engineering. (See "Comparing National Efforts at Technology Foresight.")

This section discusses U.S. "competitiveness," broadly defined here as the ability of U.S. firms to sell products in the international marketplace. A great deal of attention is given to science-based industries producing products that embody above-average levels of R&D in their development (hereafter referred to as *high-tech industries*). The Organisation for Economic Co-operation and Development (OECD) currently identifies four industries as high-tech based on their high R&D intensities: aerospace, computers and office machinery, electronics-communications, and pharmaceuticals.[2]

There are several reasons why high-tech industries are important to nations.

◆ High-tech firms are associated with innovation. Firms that innovate tend to gain market share, create new product

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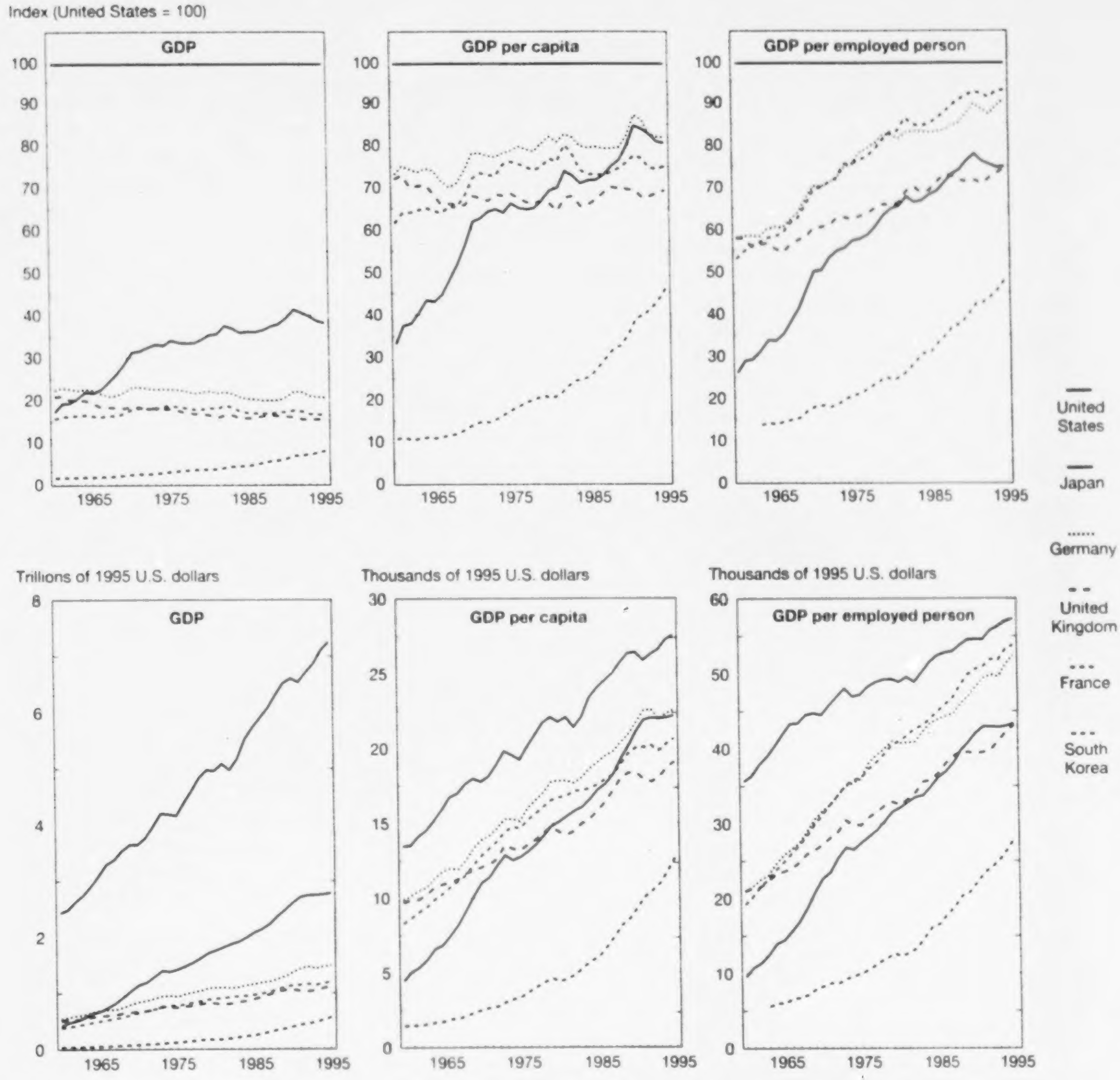
[1] In this chapter, high-tech industries are identified using R&D intensities calculated by the Organisation for Economic Co-operation and Development. There is no single preferred methodology for identifying high-technology industries. The identification of those industries considered to be high-tech has generally relied on a calculation comparing R&D intensities. R&D intensity, in turn, has typically been determined by comparing industry R&D expenditures and/or numbers of technical people employed (i.e., scientists, engineers, technicians) to industry value added or to the total value of its shipments.

[2] In designating these high-tech industries, OECD took into account both direct and indirect R&D intensities for 10 countries: the United States, Japan, Germany, France, the United Kingdom, Canada, Italy, the Netherlands, Denmark, and Australia. Direct intensities were calculated by the ratio of R&D expenditure to output (production) in 22 industrial sectors. Each sector was given a weight according to its share in the total output of the 10 countries using purchasing power parities as exchange rates. Indirect intensity calculations were made using technical coefficients of industries on the basis of input-output matrices. OECD then assumed that for a given type of input and for all groups of products, the proportions of R&D expenditure embodied in value added remained constant. The input-output coefficients were then multiplied by the direct R&D intensities. For further details concerning the methodology used, see OECD (1993).

Figure 6-1.
International economic comparisons



NOTE: Country GDPs were determined with 1993 purchasing power parities using the Elteto-Köves-Szulc (EKS) aggregation method and 1995 U.S. dollars.

See appendix tables 6-1, 6-2, and 6-3.

Science & Engineering Indicators – 1998

markets, and/or use resources more productively (NRC 1996 and Tassey 1995).

- High-tech firms are associated with high value-added production and success in foreign markets, which helps to support higher compensation to the workers they employ. (See "High-Tech Industries Continue to Show Higher Value Added Than Other Manufacturing Industries.")
- Industrial R&D performed by high-tech industries has other spillover effects. These effects benefit other commercial sectors by generating new products and processes that can often lead to productivity gains, business expansions, and the creation of high-wage jobs (Nadiri 1993, Tyson 1992, and Mansfield 1991).

Comparing National Efforts at Technology Foresight

Technology foresight is a tool used by many nations in the S&T priority-setting process. It can be defined as a systematic process for looking into the future to identify important technologies for the purpose of aiding in policy formation, planning, and decisionmaking. Most of the national technology foresight exercises conducted in recent years have involved the administration of a Delphi survey or the generation of a list of critical technologies. Whatever the methodology used, the findings of most of these exercises have included the identification of important technologies and an assessment of relative national position in those technologies identified as important.

The *Delphi survey approach* to technology foresight attempts to forecast technological developments over the long-term (20- to 30-year) future. First developed by the RAND Corporation in the 1950s, Delphi survey techniques have been used for technology foresight purposes in Japan since 1971 and in Germany, France, and the United Kingdom over the past decade. In the Delphi process, many experts receive two or more rounds of surveys in which they are asked to respond to a detailed questionnaire covering different technological developments. The technological developments themselves are not considered to be inherently important; they are only the starting points on which the survey is based. Respondents are asked to rate each development on several measures, including degree of importance for factors such as wealth creation or quality of life and expected date of realization. Respondents are also asked to rate the relative position of different countries in each technological development, based on a certain criterion such as level of R&D activity. Between survey rounds, the experts receive a summary of all responses to allow them to reconsider their assessments in light of those provided by their peers.

The *critical technologies approach* involves the generation of a list of technologies deemed critical for a country's future. Most lists also provide assessments, based on expert opinion, of relative national position in those technologies identified as critical. In recent years, critical technologies lists have been developed in the United States, Germany, and France. The definition of critical, the criteria for determining criticality, and the criteria for making assessments of national position vary by study. Among the factors considered in different studies are the importance for economic competitiveness, effect on the environment, relevance for national security, and contribution to the quality of life. Critical technologies are sometimes defined as those that are generic, or "precompetitive," and that have the potential for application in many industrial sectors. Lists of critical technologies are usually developed using a time frame of about 10 years.

Across these different types of national foresight studies, there is some agreement about which categories are useful for classifying important future technologies. The broad technological categories considered important in most studies include biotechnology and life sciences, energy, environment, transportation, information and communications, manufacturing processes, management and business, and materials.

Nations have designated different subfields within these broad technological categories as important to them; this complicates further attempts at comparing the various national technology assessments. Some technologies, however, have been identified by several studies as important; these include advanced ceramics, nanotechnology, biocompatible materials, nuclear waste storage, broadband communications, optical technology, catalysis, renewable energy, flat display technology, semiconductors, intelligent transportation systems, and signal processing.

Besides identifying important technologies and the categories under which these can be classified, most foresight exercises also address the issue of national position in important S&T fields. Self-assessments of relative position are made at both the category and individual technology levels. However, these assessments are difficult to compare across countries because they use different methodologies, criteria, and measures. (See text table 6-1.)

The Importance of High-Technology Industries

The global market for high-tech goods is growing at a faster rate than that for other manufactured goods, and economic activity in high-tech industries is driving national economic growth around the world.[3] Over the 15-year period examined (1980-95), high-tech production grew at an inflation-adjusted average annual rate of nearly 6 percent compared with a rate of 2.4 percent for other manufactured goods.[4] Global economic activity was especially strong at the end of the period (1993-95), when high-tech industry output grew at over 8 percent per year—more than twice the rate of growth for all

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[3] The WEFA/ICF Global Industry Model database reports production data by 68 countries and accounts for over 97 percent of global economic activity.

[4] Service sector industries grew at an average annual inflation-adjusted rate of 3.3 percent during this period.

Text table 6-1.

Comparison of assessments of relative technological position in international foresight exercises

	U.S. critical technologies	Japanese Delphi	German Delphi	French Delphi	U.K. Delphi	French critical technologies	German critical technologies	Australia foresight study
Type of position assessed	Technological position	R&D level	R&D leadership	R&D leadership	S&T capability *(also innovation capacity, production capability or service delivery, and exploitation and commercialization potential)*	Scientific position *(also industrial position)*	Competitive position	Share of international scientific publications and citations
Countries compared	U.S., Japan, and Europe[a]	Japan, "other countries"	Germany, Japan, U.S., "other countries"	France, Germany, Japan, U.S.[b]	United Kingdom	France[c]	Germany	Australia
Measurement scale used	U.S. has a substantial lead U.S. has a slight lead U.S. is on par U.S. slightly lags U.S. substantially lags	Measured as mean percentage of respondents, across topics, saying that: Japan is more advanced Japan is equivalent to other countries Other countries are more advanced	Measured as mean percentage of respondents, across topics, saying that: Germany is the leader Japan is the leader U.S. is the leader Other countries are leaders	Measured as mean percentage of respondents, across topics, saying that: France is the leader Germany is the leader Japan is the leader U.S. is the leader	Measured as mean percentage of respondents, across topics, saying that the: U.K. is at leading edge U.K. is an average performer U.K. is lagging behind	Strong Moderate Weak Nonexistent	Strong Average Limited	Position assessed relative to other scientific areas and interpreted as: Strong Average Weak

NOTES: Foresight reports are from the following sources: **U.S.**—U.S. Office of Science and Technology Policy (U.S. OSTP) *National Critical Technologies Report* (Washington, DC: National Critical Technologies Panel, 1995); **Japanese**—National Institute of Science and Technology Policy (NISTP), *The Fifth Technology Forecast Survey—Future Technology in Japan*, NISTP Report No. 25 (Tokyo: Science and Technology Agency, 1992); **German Delphi**—NISTP and Fraunhofer Institute for Systems and Innovation Research, *Outlook for Japanese and German Future Technology: Comparing Japanese and German Technology Forecast Surveys*, NISTP Report No. 33 (Tokyo: Science and Technology Agency, 1994); **French Delphi**—Ministère de l'Enseignement Supérieur et de la Recherche, *Enquête sur les Technologies du Futur par la Méthode Delphi: Présentation des Résultats Synthèse et Commentaires* (Strasbourg: BETA, CNRS, Université Louis Pasteur, 1995) [note that this report was not completely accepted by the French Government because of methodological concerns]; **U.K.**—D. Lovendge, L. Georghiou, and M. Nedeva, *United Kingdom Technology Foresight Programme: Delphi Survey* (London: HMSO, 1995); **French critical technologies**—Ministère de l'Industrie, *Les Technologies Clés pour l'Industries Française à l'Horizon 2000* (Paris: 1995); **German critical technologies**—H. Grupp, "Technology at the Beginning of the 21st Century," *Technology Analysis and Strategic Management*, Vol. 6, No. 4: 379-409; and **Australian**—ASTEC, *Developing Long-Term Strategies for Science and Technology in Australia: Findings of the Study Matching Science and Technology to Future Needs 2010* (Canberra: AGPS, 1996).

[a] Europe's position is "treated as an aggregate and assessments are based on the best demonstrated capability in any European country rather than on average across countries"(U.S. OSTP 1995, p. 191).

[b] The French Delphi also gave respondents the choice of "other countries," but the report did not include those responses in all calculations for methodological reasons.

[c] The French critical technologies report also assessed the scientific and industrial positions of Europe.

SOURCE: Based on the analysis and synthesis of national technology foresight reports in Mogee Research & Analysis Associates, "SGER: Comparing Assessments of National Position in Key Science & Technology Fields," report prepared under National Science Foundation SGER Grant No. SRS-9618668 (Washington, DC: 1997).

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other manufacturing industries. (See figure 6-2 and appendix table 6-5.) Output by the four high-tech industries—those identified as being the most research intensive—represented 7.6 percent of global production of all manufactured goods in 1980; by 1995, this output represented 12 percent.

During the 1980s, the United States and other high-wage countries increasingly moved resources toward the manufacture of technology-intensive goods. In 1989, U.S. high-tech manufactures represented nearly 13 percent of total U.S. production of manufactured output, up from 10.4 percent in 1980. High-tech manufactures also accounted for growing shares of total production for European nations, but the transition to high tech in Europe during the 1980s was most prominent in the United Kingdom's economy. High-tech manufactures represented just 9 percent of the United Kingdom's total manufacturing output in 1980, but jumped to 13 percent by 1989. The Japanese economy led all other major industrialized countries in its concentration on high-tech industries. In 1980, high-

High-Tech Industries Continue to Show Higher Value Added Than Other Manufacturing Industries

By definition, the concept of manufacturing value added seeks to measure the contribution of manufacturing activity to a nation's economy (as measured by gross domestic product). (See Greenwald and Associates 1984 and Pearce 1983.) At the firm level, the measurement nets out (removes) from the value of the final output the value of purchased inputs to the production process. At the national level, the measurement nets out foreign-supplied inputs from the value of the nation's final output—thereby determining domestic content of production for an industry or set of industries.

New data from OECD permit comparison of domestic content in high-tech industries and all other manufacturing industries for several countries. Examination of these data shows that high-tech industries continue to incorporate more domestic content in their manufacturing operations than do other manufacturing industries; this trend, however, is not consistent for all countries nor necessarily true for each of the four high-tech industries (i.e., aircraft, communications, office and computers, drugs and medicines). (See text table 6-2.) For example, about 43 percent of the final output by U.S. high-tech industry in 1993 is attributed to domestic value added, compared with 35 percent in all other U.S. manufacturing industries. The difference in value added as a proportion of final output between these two sectors was much larger in Germany and much less in Japan.

Within each country, trends for individual high-tech industries varied. The U.S. drugs and medicines industry, at 56 percent, had the highest ratio of value added among the four U.S. high-tech industries in 1993; the computer/office hardware industry showed lower value added in its U.S. manufacturing operations (about 28 percent) than the average for all other manufacturing. The relative value-added profile for Japan's high-tech industries was similar to that of the United States.

The impact of the global economy is also apparent from an examination of these data. In high-wage countries like the United States and Germany, domestic content in manufacturing industries fell between 1973 and 1993, while domestic content rose in lower wage countries such as South Korea and Spain. (See appendix table 6-4.)

Text table 6-2.
Proportion of manufacturing final output attributed to domestic content (value added/production)
(Percentages)

	1973	1983	1993
United States			
Total manufacturing	37.4	33.8	36.1
High-tech manufacturing	44.7	46.1	42.6
Aircraft	42.1	49.4	32.6
Communications	44.3	45.0	51.1
Office & computers	44.5	37.7	27.9
Drugs & medicines	54.2	54.2	56.4
Other manufacturing	36.8	32.3	35.1
Japan			
Total manufacturing	33.5	31.5	37.1
High-tech manufacturing	40.6	37.9	37.2
Aircraft	47.1	43.8	41.7
Communications	37.5	34.8	34.8
Office & computers	35.6	34.3	31.7
Drugs & medicines	58.7	58.0	61.8
Other manufacturing	32.9	30.7	37.1
Germany[a]			
Total manufacturing	37.4	35.9	37.1
High-tech manufacturing	52.4	54.5	48.9
Aircraft	45.8	39.0	42.7
Communications	50.0	53.3	48.0
Office & computers	83.1	76.4	55.4
Drugs & medicines	47.9	51.5	49.7
Other manufacturing	36.4	34.5	36.0

NA = not available

[a] Germany's data are for 1976, 1983, and 1992; data for all but 1992 are for West Germany only.

See appendix table 6-4. *Science & Engineering Indicators – 1998*

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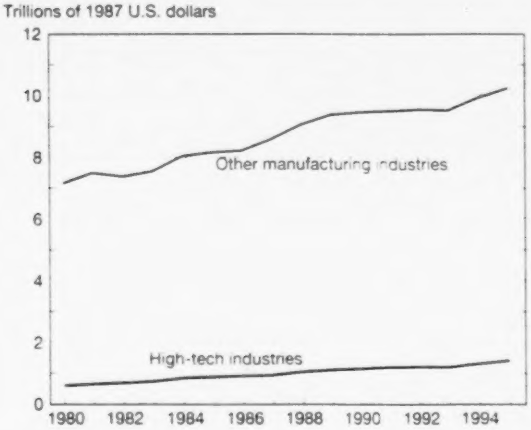
tech manufactures accounted for about 10 percent of total Japanese production, rose to 13 percent in 1984, and then increased to 15.3 percent in 1989.

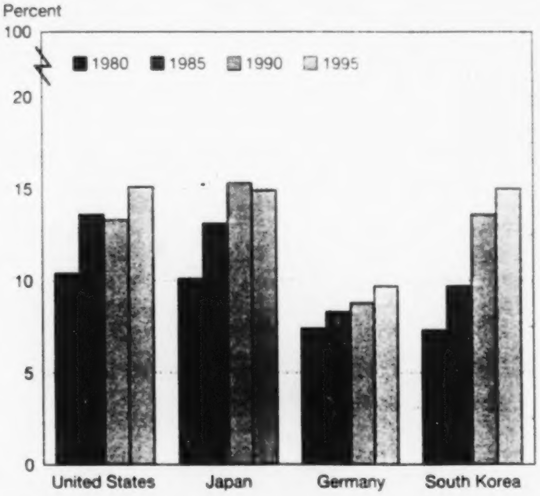
Data for the 1990s show an increased emphasis on high-tech manufactures among the major industrialized countries. (See figure 6-3.) In 1995, high-tech manufactures are estimated to represent 15 percent of manufacturing output in both the United States and Japan, 14 percent in the United Kingdom, and 10 percent each in France and Germany. Two other Asian countries, China and South Korea, typify how important R&D-intensive industries have become to the newly industrialized economies. In 1980, high-tech manufactures accounted for just 4 percent of China's total manufacturing output; this proportion jumped to 11.4 percent in 1989 and then reached 12.5 percent in 1995—more than for France or Germany. In 1995, high-tech manufacturing in South Korea accounts for about the same percentage of total output as in Japan and the United States (15 percent).

Figure 6-2.
Global sales of manufactured products



See appendix table 6-5. *Science & Engineering Indicators - 1998*

Figure 6-3.
High-tech industries' share of total manufacturing output



See appendix table 6-5. *Science & Engineering Indicators - 1998*

Share of World Markets

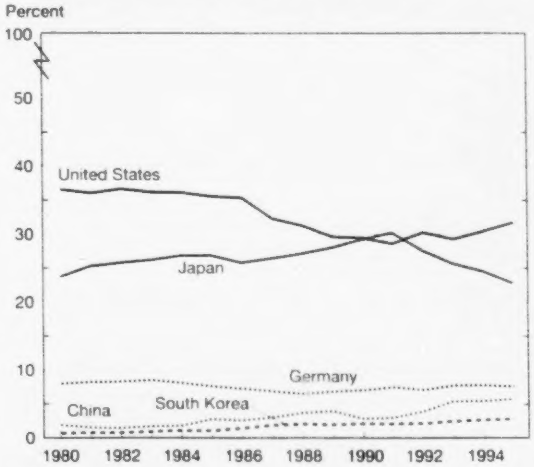
Throughout the 1980s, the United States was the leading producer of high-tech products, responsible for over one-third of total world production from 1980 to 1986, and for about 30 percent of world production for the rest of the decade. While U.S. world market share continued to decline into the early 1990s, the downward trend reversed in 1992. The U.S. share of the world market for high-tech manufactures grew irregularly after 1991. By 1995, U.S. high-tech industries had regained much of the market share lost during the previous decade. (See figure 6-4.) In 1995, production by U.S. high-tech industry accounted for nearly 32 percent of world high-tech production.

While U.S. high-tech industry struggled to maintain market share during the 1980s, the Japanese global market share in high-tech industries followed a path of steady gains. In 1989, Japan accounted for 28 percent of the world's production of high-tech products, moving up 4 percentage points since 1980. Japan continued to gain on the United States until 1991 when, for the first time, it moved past the United States to become the world's leading high-tech producer. Since then, however, Japan's market share has dropped steadily, falling to under 23 percent of world production in 1995 after accounting for more than 30 percent four years earlier.

By comparison, European nations' share of world high-tech production is much lower. Germany produced about 8 percent of world high-tech production in 1980, under 7 percent in 1989, and nearly 8 percent once again by 1995. Shares for both France and the United Kingdom fluctuated between 4 and 5 percent throughout the 15-year period examined.

China has made the most dramatic gains since 1980, although these gains were made in spurts. During the first half of the 1980s, China's market share moved downward, hovering around 2 percent of world high-tech production. By 1989, the country's share had doubled. After a one-year decline down to 2.9 percent in 1990, China's high-tech production increased significantly; by 1995, the country accounted for nearly 6 percent of world high-tech output.

Figure 6-4.
Country share of global high-tech market



NOTE: German data are for the former West Germany only.
See appendix table 6-5. *Science & Engineering Indicators - 1998*

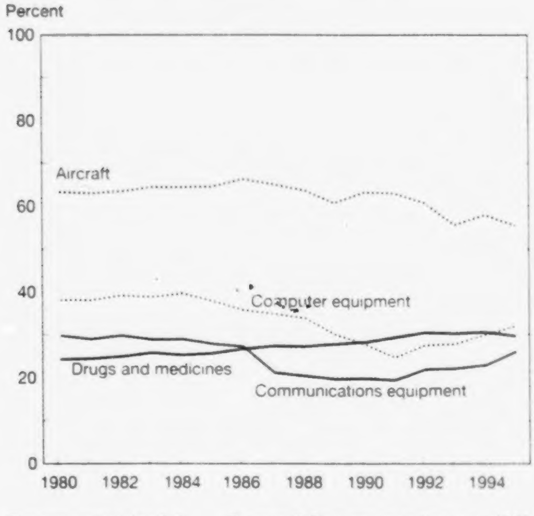
Global Competitiveness of Individual Industries

In each of the four industries that make up the high-tech group, the United States maintained strong, if not leading, market positions over the 15-year period examined. Yet competitive pressures from a growing cadre of high-tech-producing nations contributed to a decline in global market share for three U.S. high-tech industries during the 1980s: aircraft, computers, and communications equipment. Since then, two of these industries—computers and, in particular, communications equipment—have reversed their downward trends and gained market share in the 1990s. (See figure 6-5.)

The U.S. aircraft industry, the nation's strongest high-tech industry in terms of world market share, was the one high-tech industry to lose market share in the 1980s and again in the 1990s. For much of the 1980s, the U.S. aircraft industry supplied about two-thirds of world demand. Within the 1980-95 period, the U.S. share of the world aircraft market peaked in 1986, when it supplied over 66 percent of world demand; it then lost market share nearly every year since. By 1995, the U.S. share had fallen to 55 percent of the world market. (See figure 6-6.) While European aircraft industries gained market share during this time, Chinese industries made especially large gains in global market share beginning in 1992. In 1980, China supplied about 3.5 percent of world aircraft shipments; by 1995, its share had increased to nearly 12 percent.

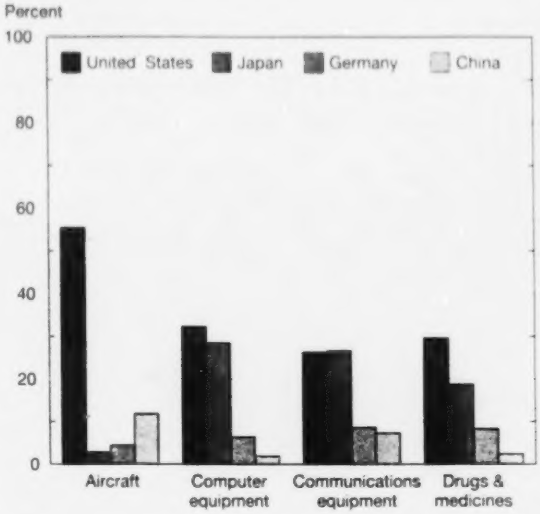
As previously noted, two U.S. high-tech industries lost market share during the 1980s and then reversed that trend during the 1990s. By 1995, the United States was the number one supplier of computer equipment in the world and in a virtual tie with Japan for number one in terms of worldwide shipments of communications equipment.

Figure 6-5.
U.S. global market share, by high-tech industry



See appendix table 6-5. *Science & Engineering Indicators – 1998*

Figure 6-6.
Global market share, by country and high-tech industry: 1995



See appendix table 6-5. *Science & Engineering Indicators – 1998*

Of the four high-tech industries, only the U.S. pharmaceutical industry managed to retain its number one ranking throughout the 15-year period. It was also the only U.S. high-tech industry that had a larger share of the global market in 1995 than in 1980.

The United States is considered a large, open market. These characteristics benefit U.S. high-tech producers in two important ways. First, supplying a market with many domestic consumers provides scale effects to U.S. producers in the form of potentially large rewards for the production of new ideas and innovations (Romer 1996). Second, the openness of the U.S. market to foreign-made technologies pressures U.S. producers to be inventive and to move toward more rapid innovation in order to maintain domestic market share.

This discussion of world market shares shows that U.S. producers are leading suppliers of high-tech products to the global market. That evaluation incorporates U.S. sales to domestic as well as foreign customers. In the next sections, these two markets are examined separately.

Exports by High-Tech Industries

While U.S. producers reaped many benefits from having the world's largest home market (as measured by gross domestic product—GDP), mounting trade deficits have led to concern about the need to expand U.S. exports. U.S. high-tech industries have traditionally been more successful than other U.S. industries in foreign markets. Consequently, high-tech industries have attracted considerable attention from policymakers as they seek ways to return the United States to a more balanced trade position.

Foreign Markets

Despite its domestic focus, the United States has been an important supplier of manufactured products in foreign markets throughout the 1980-95 period. In fact, from 1992 to 1995, the United States was the leading nation exporter of manufactured goods, accounting for between 12.1 and 12.8 percent of world exports. U.S. high-tech industries have contributed to this strong export performance of the nation's manufacturing industries.

Over the same 15-year period, U.S. high-tech industries accounted for between 19 and 26 percent of world high-tech exports—at times twice the level achieved by all U.S. manufacturing industries. The peak was reached in 1980, and U.S. market share has fallen fairly consistently since then. In 1995, the latest year for which data are available, exports by U.S. high-tech industries accounted for 19.2 percent of world high-tech exports; Japan was second, accounting for 11.9 percent; followed by the United Kingdom and Germany, with 7.2 percent and 6.9 percent, respectively.

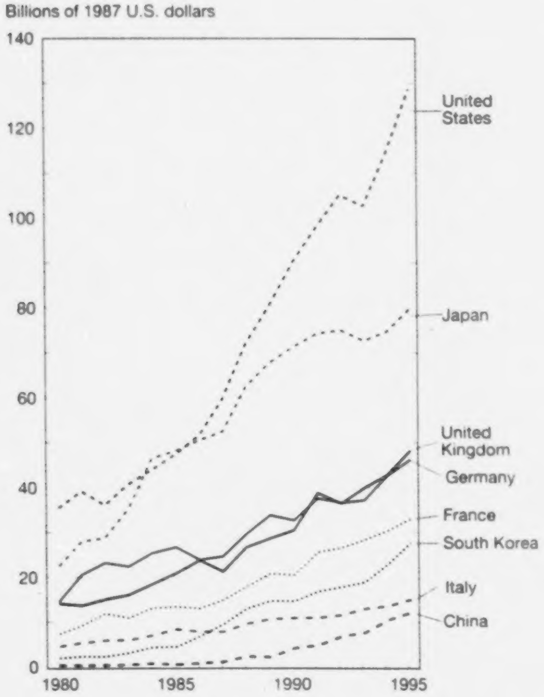
The drop in U.S. share over the 15-year period is in part the result of the emergence of high-tech industries in newly industrialized economies, especially within Asia. South Korea is one example. (See figure 6-7.) In 1980, high-tech industries in South Korea accounted for about 1.4 percent of world high-tech exports. That market share doubled by 1986. The latest data for 1995 show South Korea's share reaching 4.1 percent, nearly twice the market share of high-tech exports held by Italy that same year.

Industry Comparisons

Throughout the 15-year period, individual U.S. high-tech industries either led in exports or were second to the leader in each of the four industries included in the high-tech grouping. The most current data, 1995, show the United States as the export leader in three industries and second in just one—drugs and medicines. (See figure 6-8.) As noted in the previous section on global market shares, the U.S. pharmaceutical industry was the only U.S. high-tech industry that consistently led the world in production and that also had a larger share of the world market in 1995 than in 1980. Since global market shares incorporate all shipments—foreign and domestic—this industry's sales to the U.S. market appear to be responsible for its gain in world market share.

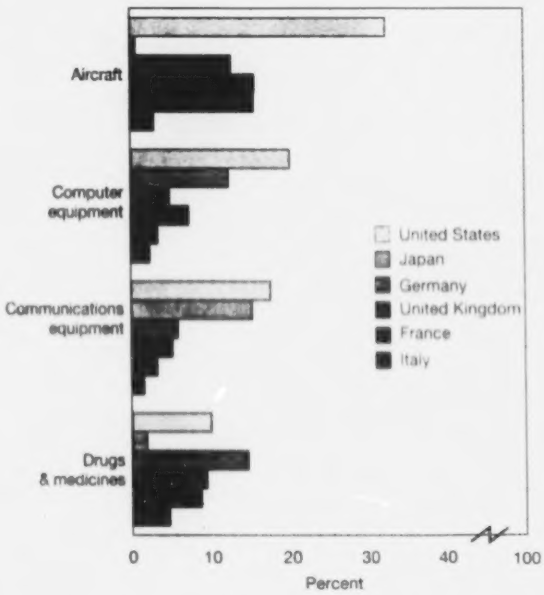
In terms of export performance, U.S. industries producing aircraft, computers, and pharmaceuticals all accounted for smaller export shares in 1995 than in 1980. The communications equipment industry was the sole U.S. high-tech industry to improve its share of world exports over the period. By

Figure 6-7.
High-tech exports



See appendix table 6-5. *Science & Engineering Indicators – 1998*

Figure 6-8.
Export market share: 1995



See appendix table 6-5. *Science & Engineering Indicators – 1998*

comparison, the share of world exports held by Japan's communications equipment industry dropped steadily after 1985—eventually falling to 15.2 percent by 1995 from a high of 36.5 percent just 10 years earlier. In addition to gains in world export share by the United States and the United Kingdom, once again the newly industrialized economies of Asia demonstrated an ability to produce high-tech goods to world-class standards and were rewarded with great success in selling to foreign markets. In 1995, South Korea supplied 6.8 percent of world communication product exports, up from just 2.7 percent in 1980. Other Asian newly industrialized economies have demonstrated similar capabilities in communications equipment.

Competition in the Home Market

A country's home market is often thought of as the natural destination for the goods and services produced by domestic firms. For obvious reasons—including proximity to the customer and common language, customs, and currency—marketing at home is easier than marketing abroad.

But with trade barriers falling and the number of foreign firms able to produce goods to world standards rising, product origin may only be one factor among many influencing the consumer's choice between competing products. Price, quality, and product performance often become equally important determinants guiding product selection. Thus, in the absence of trade barriers, the intensity of competition faced by domestic producers in their home market can approach—and, in some markets, may even exceed—the level of competition faced in foreign markets. Explanations for U.S. competitiveness in foreign markets may be found in the two dynamics of the U.S. market: the existence of tremendous domestic demand for the latest advanced technology products and the degree of world-class competition that continually pressures U.S. industry toward innovation and discovery.

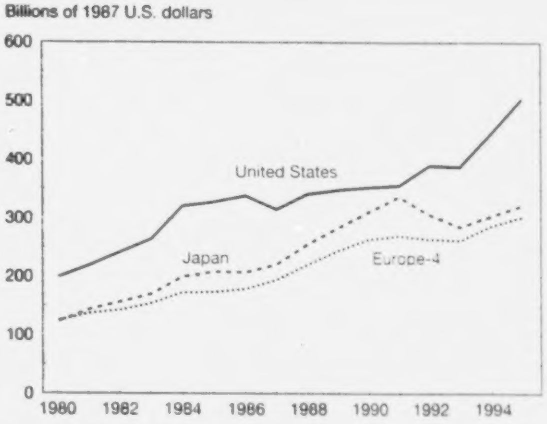
National Demand for High-Tech Products

Demand for high-tech products in the United States far exceeds that in any other single country and is larger than the combined markets of the four largest European nations (Germany, the United Kingdom, France, and Italy). (See figure 6-9.) This was consistently the case for the entire 1980-95 period. Japan, too, has large domestic demand for high-tech products, and was the second largest market for high-tech products in the world—its demand was much closer in size to that of the United States than to the next largest high-tech market, Germany.

National Producers Supplying the Home Market

Throughout the 1980-95 period, the world's largest market for high-tech products, the United States, was served primarily by domestic producers—yet demand was increasingly met by a growing number of foreign suppliers. (See figure 6-10.) In 1995, U.S. producers supplied about 73 percent of the home market for high-tech products (i.e., aerospace, computers, communications equipment, and pharmaceuticals); however, in 1980, U.S. producers' share was much higher, nearly 92 percent.

Figure 6-9.
Apparent consumption of high-tech products



NOTE: Europe-4 refers to the four largest European economies: Germany, France, the United Kingdom, and Italy.

See appendix table 6-5. *Science & Engineering Indicators – 1998*

Other countries have experienced similar increased foreign competition in their domestic markets. This is especially true in Europe. A more economically unified European market has had the effect of making Europe an even more attractive market to the rest of the world. Rapidly rising import penetration ratios in the four large European nations during the latter part of the 1980s and throughout the first half of the 1990s reflect these changing circumstances. These data also highlight greater trade activity in European high-tech markets when compared with product markets for less technology-intensive manufactures.

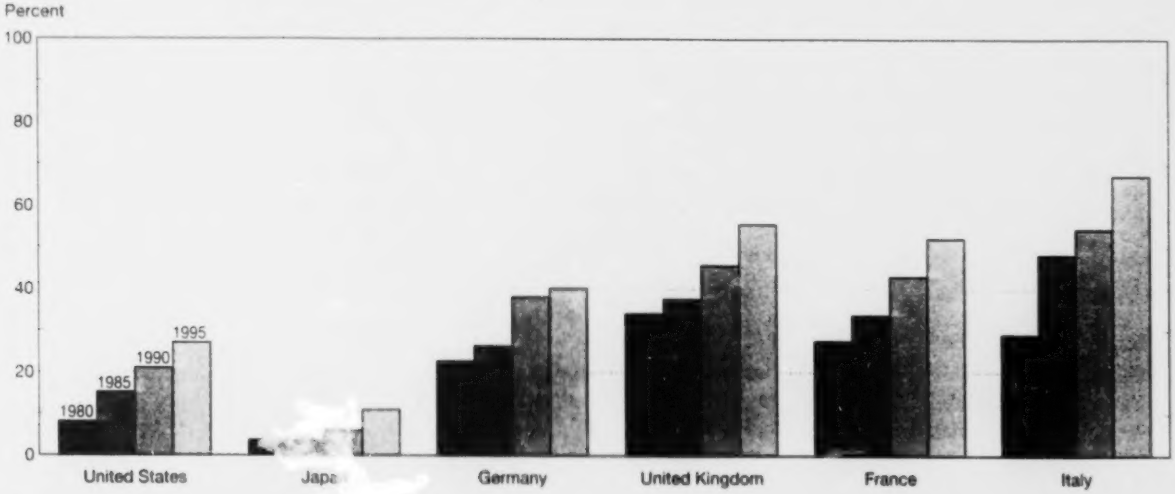
The Japanese home market, the second largest national market for high-tech products and historically the most self-reliant of the major industrialized countries, also increased its purchases of foreign technologies over the 15-year period, albeit slowly. In 1980, imports of high-tech manufactures supplied less than 4 percent of Japanese domestic consumption, rising to 5.6 percent in 1989, and then to 11 percent by 1995.

U.S. Trade Balance

The U.S. Bureau of the Census has developed a classification system for exports and imports of products that embody new or leading-edge technologies. This classification system allows trade to be examined in 10 major technology areas that have led to many leading-edge products. These 10 advanced technology areas are:

- **biotechnology**—the medical and industrial application of advanced genetic research toward the creation of new drugs, hormones, and other therapeutic items for both agricultural and human uses;
- **life science technologies**—application of scientific advances (other than biological) to medical science (for

Figure 6-10.
Import share of domestic high-tech markets



See appendix table 6-5.

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example, medical technology advances such as nuclear resonance imaging, echocardiography, and novel chemistry, coupled with new production techniques for the manufacture of drugs, have led to new products that allow for the control or eradication of disease);

- **opto-electronics**—development of electronic products and components that involve emission or detection of light, including optical scanners, optical disk players, solar cells, photosensitive semiconductors, and laser printers;
- **computers and telecommunications**—development of products that process increasing volumes of information in shorter periods of time, including fax machines, telephone switching apparatus, radar apparatus, communications satellites, central processing units, computers, and peripheral units such as disk drives, control units, modems, and computer software;
- **electronics**—development of electronic components (except opto-electronic components), including integrated circuits, multilayer printed circuit boards, and surface-mounted components, such as capacitors and resistors, that result in improved performance and capacity and, in many cases, reduced size;
- **computer-integrated manufacturing**—development of products for industrial automation, including robots, numerically controlled machine tools, and automated guided vehicles that allow for greater flexibility in the manufacturing process and reduce the amount of human intervention;
- **material design**—development of materials, including semiconductor materials, optical fiber cable, and videodisks, that enhance application of other advanced technologies;
- **aerospace**—development of technologies, such as most new military and civil airplanes, helicopters, and spacecraft (with the exception of communications satellites), turbojet aircraft engines, flight simulators, and automatic pilots;
- **weapons**—development of technologies with military applications, including guided missiles, bombs, torpedoes, mines, missile and rocket launchers, and some firearms; and
- **nuclear technology**—development of nuclear production apparatus, including nuclear reactors and parts, isotopic separation equipment, and fuel cartridges (nuclear medical apparatus is included in life science rather than this category).

To be included in a category, a product must contain a significant amount of one of the leading-edge technologies, and the technology must account for a significant portion of the product's value.[5] Because the characteristics of products exported by the United States are likely to differ from the products it imports, experts evaluated exports and imports separately.

The Importance of Advanced Technology Product Trade to Overall U.S. Trade

U.S. trade in advanced technology products accounted for 17 to 20 percent of all U.S. trade (exports plus imports) in merchandise between 1990 and 1996. (See text table 6-3.) Total U.S. trade exceeded $1.4 trillion in 1996; $285 billion involved trade in advanced technology products. Trade in advanced technology products accounts for a much larger share of U.S. exports than of imports (25 percent versus nearly 16 percent in 1996) and makes a positive contribution to the overall balance of trade. After several years in which the surplus generated by trade in advanced technology products declined, preliminary data for 1996 show a larger surplus than in 1995. (See figure 6-11 and text table 6-3.)

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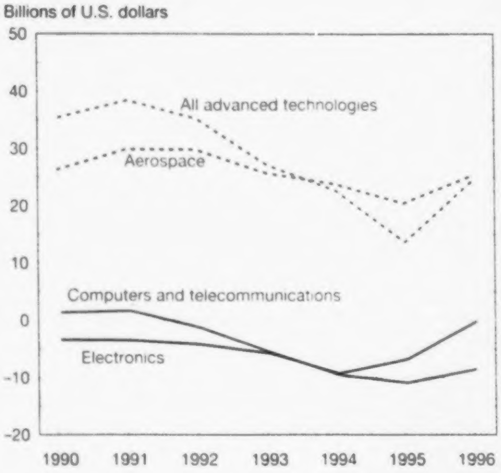
[5] The advanced technology product system of trade data discussed here allows for a highly disaggregated, focused examination of technology embodied in traded goods. To minimize the impact of subjective classification, the judgments offered by government experts are subsequently reviewed by external experts.

Technologies Generating a Trade Surplus

Between 1990 and 1995, the U.S. trade surplus in software technology doubled, and trade in computer-integrated manufacturing technologies—those used to automate the manufacturing process—generated a sizable surplus. During this same period, trade in aerospace technologies consistently produced large, albeit declining, trade surpluses for the United States. Aerospace technologies generated a net inflow of $26 billion in 1990, and almost $30 billion in 1991 and 1992; the U.S. trade surplus in aerospace technologies then declined 14 percent in 1993, 9 percent in 1994, and 14 percent in 1995. While U.S. aerospace companies continue to lead the world in aircraft production and global shipments, Europe's aerospace industry now challenges U.S. companies' preeminence both at home and in foreign markets. The impact of Europe's Airbus is evident in the trade data. In 1990, U.S. trade in aerospace technologies with Germany, the United Kingdom, France, and Italy produced a $5.5 billion trade surplus. In 1995, the U.S. trade surplus with Europe was less than half that amount ($2 billion).

In 1990, opto-electronics and electronics products were the only advanced technology areas that produced net trade deficits for the United States. However, since 1992, the United States has had trade deficits in three areas: opto-electronics, electronics, and computers and telecommunications. Trade deficits with several Asian economies in these three advanced technology areas now exceed the trade surpluses generated from trade with other countries.

Figure 6-11.
U.S. trade balance in top three advanced technology products



See appendix table 6-6. *Science & Engineering Indicators – 1998*

U.S. Royalties and Fees Generated From Intellectual Property

The United States has traditionally maintained a large surplus in international trade of intellectual property. Firms trade intellectual property when they license or franchise proprietary technologies, trademarks, and entertainment products to entities in other countries. These transactions generate net revenues in the form of royalties and licensing fees.

U.S. Royalties and Fees From All Transactions

U.S. receipts from all trade in intellectual property reached $26.9 billion in 1995, a 21 percent increase over 1994. The

Text table 6-3.
U.S. international trade in merchandise
(Billions of U.S. dollars)

	1990	1991	1992	1993	1994	1995	1996
Total exports	393.0	421.9	447.5	464.8	512.4	575.9	611.5
Technology products (percent)	24.1	24.1	23.9	23.3	23.6	24.0	25.3
Other merchandise (percent)	75.9	75.9	76.1	76.7	76.4	75.0	74.7
Total imports	495.3	488.1	532.4	580.5	663.8	749.4	799.3
Technology products (percent)	11.0	12.0	13.5	13.0	14.8	16.7	16.3
Other merchandise (percent)	88.0	87.0	86.5	86.0	85.2	83.3	83.7
Total trade	888.3	910.0	979.9	1,045.3	1,176.2	1,325.3	1,410.8
Technology products (percent)	17.3	18.1	18.3	18.1	18.6	19.9	20.2
Other merchandise (percent)	82.7	81.9	81.7	81.9	81.4	80.1	79.8

NOTE: Total trade is the sum of total exports and total imports.

SOURCE: U.S. Bureau of the Census, Foreign Trade Division, <<http://www.fedstats.gov>>, 1997. *Science & Engineering Indicators – 1998*

1995 surplus continued a steady upward trend, which has resulted in a doubling of U.S. receipts in just six years. (See appendix table 6-7.) During the 1987-95 period, U.S. receipts were generally four to five times as large as U.S. payments to foreign firms for intellectual property. Most (about 75 percent) of the transactions involved exchanges of intellectual property between U.S. firms and their foreign affiliates.[6] (See figure 6-12.)

Exchanges of intellectual property among affiliates continue to grow faster than those among unaffiliated firms. This trend suggests a growing internationalization of U.S. business and a desire to retain a high level of control on any intellectual property leased overseas.

U.S. Royalties and Fees From Trade in Technical Knowledge

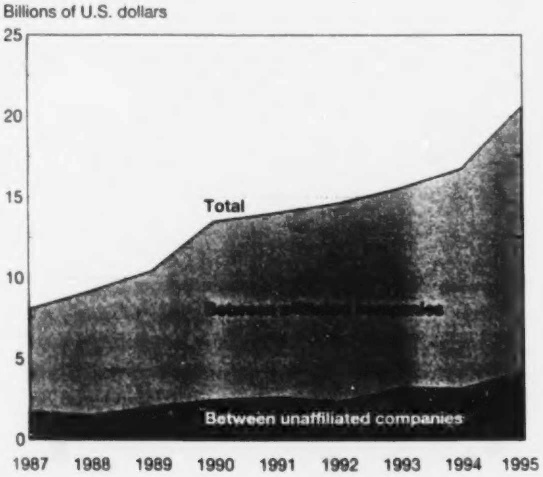
Data on royalties and fees generated by trade in intellectual property can be further disaggregated to reveal U.S. trade in technical know-how. These data describe transactions between unaffiliated firms where prices are set through a market-based negotiation. Therefore, they better reflect the exchange of technical know-how and its market value at a given point in time than do data on exchanges among affiliated firms. When receipts (sales of technical know-how) consistently exceed payments (purchases), these data may indicate a comparative advantage in the creation of industrial technology. The record of resulting receipts and payments also provides an indicator of the production and diffusion of technical knowledge.

The United States is a net exporter of technology sold as intellectual property. Royalties and fees received from foreign firms have been, on average, three times those paid out by U.S. firms to foreigners for access to their technology. U.S. receipts from such technology sales exceeded $3.3 billion in 1995, up from $3.0 billion in 1994, and nearly double that reported for 1987. (See figure 6-13 and appendix table 6-8.)

Japan is the largest consumer of U.S. technology sold as intellectual property. In 1995, Japan accounted for over 45 percent of all such receipts, while the European Union (EU) countries together represented about 20 percent. Another Asian country, South Korea, is the second largest consumer of U.S. technology sold as intellectual property; it has maintained that position since 1988, when it accounted for 5.5 percent of U.S. receipts. South Korea's share rose to 10.7 percent in 1990, and to 17.6 percent in 1995.

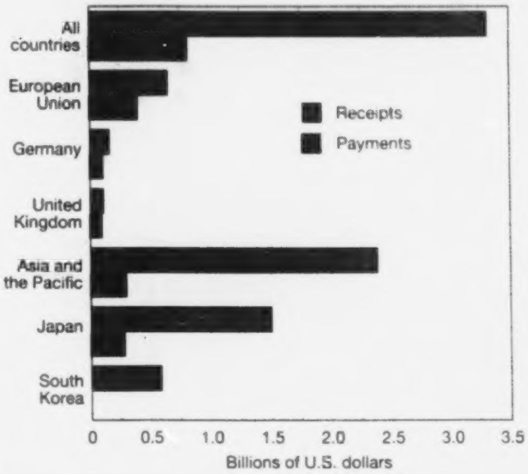
To a large extent, the U.S. surplus in the exchange of intellectual property is driven by trade with Asia. In 1995, U.S. receipts (exports) from technology licensing transactions were eight times U.S. firm payments (imports) to Asia. As previously noted, Japan and South Korea were the biggest customers for U.S. technology sold as intellectual property—together, these countries accounted for over 50 percent of total receipts in 1995.

Figure 6-12.
U.S. trade balance of royalties and fees



See appendix table 6-7. *Science & Engineering Indicators – 1998*

Figure 6-13.
U.S. royalties and fees generated from the exchange of industrial processes between unaffiliated companies: 1995



See appendix table 6-8. *Science & Engineering Indicators – 1998*

The U.S. experience with Europe has been very different from that with Asia. Over the years, U.S. trade with Europe in intellectual property has bounced back and forth, showing either a small surplus or deficit each year. In 1995,

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[6] An affiliate refers to a business enterprise located in one country that is directly or indirectly owned or controlled by an entity of another country to the extent of 10 percent or more of its voting stock for an incorporated business or an equivalent interest for an unincorporated business.

U.S.-Europe trade produced the largest surplus in the nine years examined, the result of a sharp decline in U.S. purchases of technical know-how from the smaller European countries.

Foreign sources for U.S. firm purchases of technical know-how have changed somewhat over the years, with increasing amounts coming from Japan. Europe still accounts for nearly 60 percent of the foreign technical know-how purchased by U.S. firms, with France, Germany, and the United Kingdom being the principal European suppliers. But, since 1990, Japan has been the single largest foreign supplier of technical know-how to U.S. firms.

International Trends in Industrial R&D

In high-wage countries like the United States, industries stay competitive in a global marketplace through innovation. Innovation can lead to better production processes and better performing products (i.e., those that are more durable, more energy efficient, etc.); it can thereby provide the competitive advantage high-wage countries require when competing with low-wage countries.

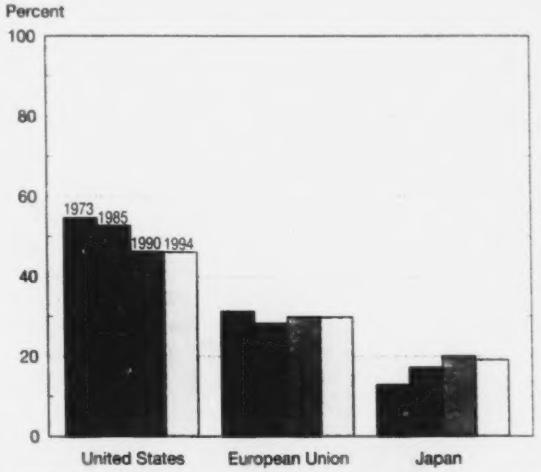
R&D activities serve as an incubator for the new ideas that can lead to new products, processes, and industries. While they are not the only source of new innovations, R&D activities conducted in industry-run laboratories and facilities are associated with many of the important new ideas that have helped shape modern technology.

U.S. industries that traditionally conduct large amounts of R&D have met with greater success in foreign markets than less R&D-intensive industries and have been more supportive of higher wages for their employees.[7] Moreover, trends in industrial R&D performance serve as leading indicators of future technological performance. This section examines these R&D trends, focusing particularly on growth in industrial R&D activity in the top R&D-performing industries of the United States and of its two major competitors in the global marketplace, Japan and the European Union.[8]

Overall Trends

The United States has long led the industrialized world in the performance of industrial R&D. Over the past two decades, however, the U.S. edge has diminished. Specifically, the U.S. share of total industrial R&D performed by all OECD member countries was 55 percent in 1973 and 46 percent in 1994.[9] (See figure 6-14.) Despite this decline, the United States remains the leading performer of industrial R&D by a wide margin, even surpassing the combined R&D of the 15-nation European Union. For its part, Japan—in keeping with its belief in the economic benefits of investments in R&D—rapidly increased R&D spending in the 1970s and 1980s, which led to a near doubling of its share of total OECD R&D by 1990. Preliminary data for 1995 indicate a 1 percentage point rise in the U.S. share, a 1 percentage point decline for Japan, and no change for the European Union.

Figure 6-14.
Percent shares of total industrial R&D in OECD countries



SOURCE: Organisation for Economic Co-operation and Development, Analytical Business Enterprise R&D Database (Paris: 1997).

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R&D Performance by Industry

The United States, the European Union, and Japan represent the three largest economies in the industrialized world and compete head to head in the international marketplace. An analysis of R&D data provides some explanation for past successes in certain product markets, provides insights into future product development, and signals shifts in national technology priorities.[10]

United States

R&D performance by U.S. industry followed a pattern of rapid growth during the 1970s, which accelerated during the early 1980s. That growth pattern stalled during the latter part of the decade and into the 1990s. When adjusted for inflation, growth in U.S. industrial R&D performance over the last decade has steadily dropped from only meager growth to actual decline in 1993 and 1994 (by 2.7 and 0.2 percent, respectively, in 1987 constant dollars).

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[7] See "U.S. Technology in the Marketplace" for a presentation of recent trends in U.S. competitiveness in foreign and domestic product markets.

[8] This section uses data from OECD's Analytical Business Enterprise R&D Database (OECD 1997) to examine trends in national industrial R&D performance. This database tracks all R&D expenditures (both defense- and nondefense-related) carried out in the industrial sector, regardless of funding source. For an examination of U.S. industrial R&D by funding source, see chapter 4.

[9] OECD member countries include Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, South Korea, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

[10] Industry-level data are occasionally estimated here in order to provide a complete time series for the 1973-94 period.

The downturn in growth would be far more dramatic were it not for the growth in R&D performed by U.S. service sector industries. While the growth in R&D performance by U.S. manufacturers has slowed since the mid-1980s, R&D performance by U.S. service sector industries has grown rapidly. (See figure 6-15.) The latest internationally comparable data on overall U.S. industrial R&D performance show the service sector's share rising from 4 percent in 1982 to 24 percent by 1992. The specific industries driving this increase in R&D performance within the U.S. service sector include those developing computer software and providing communication services.

Overall, the U.S. aerospace and communications equipment industries have consistently been the largest performers of R&D in this country. Comparing performance in 1984 and 1994, however, shows a shift in the nation's R&D emphasis. More R&D is being performed in the automotive industry, in the industry producing scientific instruments, and in the service sector industries. Service sector industries as a group accounted for a larger share of U.S. industrial R&D performance than either the aerospace industry or the automobile industry—the top two R&D-performing industries in the U.S. manufacturing sector in 1994.

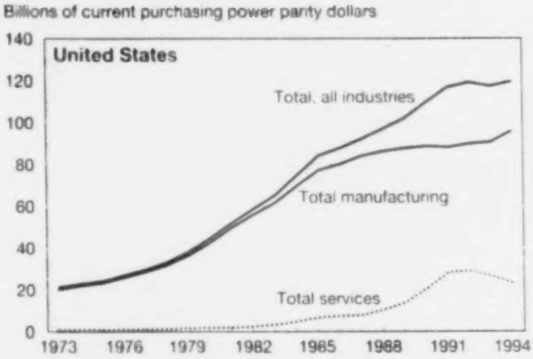
Japan

During the 1970s, R&D performance in Japanese industries grew at a higher rate than in the United States. Japanese industry continued to expand its R&D spending rapidly through 1985, more than doubling the annualized growth of the previous decade. Japanese industrial R&D spending slowed somewhat during the second half of the 1980s, but the country still led all other industrialized nations in terms of average annual growth in industrial R&D. Unlike the declining trend observed for manufacturing industries in the United States, Japanese manufacturing industries consistently accounted for over 95 percent of all R&D performed by Japanese industry. R&D in Japanese service sector industries appears to have accelerated during the 1990s, but the country's industrial R&D continues to be dominated by the manufacturing sector. (See figure 6-15.)

An examination of growth trends for the top five R&D-performing industries in Japan reflects that country's longstanding emphasis on electronics (including consumer electronics and all types of audiovisual equipment). This industry was the leading performer of R&D throughout the period reviewed. Japan's motor vehicle industry was the third leading R&D performer in 1973, but rose to number two in 1980 and remained at that level through 1992. Japanese automakers earned a reputation for high quality and value during these years, which earned them increasingly larger shares of the global car market.

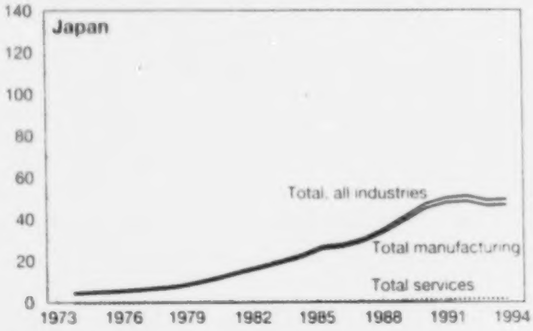
Electrical machinery producers are also among the largest R&D performers in Japan and have maintained high R&D growth throughout the period examined. By 1994, in fact,

Figure 6-15.
Industrial R&D performance



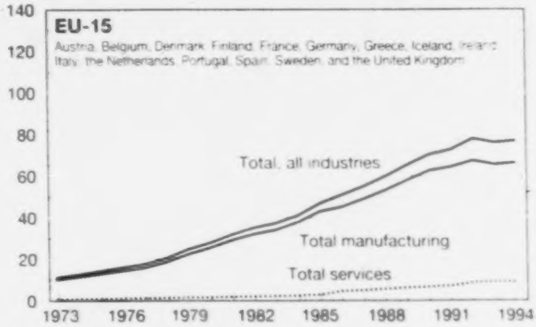
Top industrial R&D performers and their share of total industrial R&D

1974		1984		1994	
Aerospace	23.1%	Aerospace	25.2%	Services (total)	19.5%
Electrical equipment & components	13.0%	Electrical equipment & components	15.9%	Aerospace	11.9%
Motor vehicles	10.4%	Office machinery & computers	10.8%	Motor vehicles	11.2%
Office machinery & computers	9.2%	Motor vehicles	8.1%	Electrical equipment & components	10.6%
Electrical machinery	8.9%	Services (total)	6.6%	Instruments	9.6%



Top industrial R&D performers and their share of total industrial R&D

1974		1984		1994	
Electrical equipment & components	15.6%	Electrical equipment & components	17.9%	Electrical equipment & components	16.5%
Industrial chemicals	14.2%	Motor vehicles	13.0%	Electrical machinery	11.2%
Non-electrical machinery	11.6%	Industrial chemicals	10.9%	Motor vehicles	11.1%
Motor vehicles	11.3%	Electrical machinery	10.5%	Industrial chemicals	10.2%
Electrical machinery	10.0%	Non-electrical machinery	8.6%	Non-electrical machinery	9.3%



Top industrial R&D performers and their share of total industrial R&D

1974		1984		1994	
Electrical equipment & components	15.1%	Electrical equipment & components	18.5%	Electrical equipment & components	15.4%
Industrial chemicals	13.9%	Industrial chemicals	12.4%	Motor vehicles	13.4%
Aerospace	13.2%	Motor vehicles	11.2%	Services (total)	11.7%
Motor vehicles	9.9%	Aerospace	10.7%	Industrial chemicals	10.4%
Electrical machinery	8.4%	Electrical machinery	7.4%	Pharmaceuticals	10.0%

See appendix tables 6-9, 6-10, and 6-11.

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this industry had moved up to become Japan's second leading R&D-performing industry. In comparison, the U.S. electrical machinery industry's ranking among the top R&D performers in the United States has dropped since 1973.

European Union

Like Japan and the United States, manufacturing industries perform the bulk of industrial R&D in the 15-nation European Union. The European Union's industrial R&D appears to be somewhat less concentrated than in the United States, but more so than in Japan. Manufacturers of electronics equipment, industrial chemicals, and motor vehicles have consistently been among the top five performers of industrial R&D in the European Union. (See figure 6-15.) In 1994, Germany led the European Union in the performance of motor vehicle and industrial chemical R&D, while France led in industrial R&D performed by communications equipment manufacturers.

R&D performed by the European Union's service sector has doubled since the mid-1980s, accounting for nearly 12 percent of total industrial R&D performed by 1994. Large increases in service sector R&D are apparent in many EU countries, but especially in the United Kingdom (23.6 percent of its industrial R&D in 1994), Italy (13.8 percent), and France (9.5 percent).

Patented Inventions

New technical inventions have important economic benefits to a nation, as they can often lead to innovations in terms of new or improved products or more efficient manufacturing processes—or even to new industries. To foster inventive activity, nations assign property rights to inventors in the form of patents, which allow the inventor to exclude others from making, using, or selling the invention. Inventors can obtain patents from government-authorized agencies for inventions judged to be new, useful, and non-obvious.

Patent data provide useful indicators of technical change and serve as a means of measuring inventive output over time.[11] Further, U.S. patenting by foreign inventors enables measurement of the levels of invention in those foreign countries (Pavitt 1985) and can serve as a leading indicator of new technological competition (Faust 1984). Patenting trends can therefore serve as an indicator—albeit one with certain limitations—of national inventive activities.[12]

This section describes broad trends in inventive activity in the United States over time by national origin of owner, patent office class, patent activity, and commerce activity. It discusses U.S. inventor patenting in foreign countries and presents data on international patenting in several "critical" technologies.

U.S. Patenting

In 1994, for the first time ever, more than 100,000 patents were issued in the United States. This record number—101,675—of new inventions resulting in new patents caps off what had been several years of steady increases since 1990. In 1995, U.S. patents granted fell short of the previous year's mark, but not by much. Once again, more than 100,000 patents were granted, with the final count reaching 101,419 in 1995.

Patents Granted to U.S. Inventors

During the mid-1980s, the number of U.S. patents awarded to U.S. inventors began to decline just as the number awarded to foreign inventors began to rise. This of course raised questions about U.S. inventive activity and whether these numbers were yet another indicator of U.S. competitiveness on the decline. By the end of the decade, however, U.S. inventor patenting picked up and continued to increase and outpace foreign inventor patenting in the United States. In 1989, there was a large jump in the number of new patents awarded to U.S. inventors; that year also marked the first time the number of patents awarded to U.S. inventors exceeded 50,000. Except for the following year (1990), the 50,000 barrier was exceeded each year thereafter. In 1995, U.S. inventors received 55,739 patents. (See figure 6-16 and appendix table 6-12.)

Inventors who work for private companies or the Federal Government commonly assign ownership of their patents to their employers; self-employed inventors typically retain ownership of their patents. Examining patent data by owner's sector of employment can therefore provide a good indication of the sector in which the inventive work was done. In 1995, 79 percent of granted U.S.-origin patents were owned by U.S. corporations.[13] (See "Top Patenting Corporations.") This percentage has increased gradually over the years.[14]

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[11] See Griliches (1990) for a survey of literature related to this point.

[12] Although the U.S. Patent and Trademark Office grants several types of patents, this discussion is limited to utility patents only, which are commonly known as "patents for inventions." Patenting indicators have several well-known drawbacks, including the following:

- ◆ **incompleteness**—many inventions are not patented at all, in part because laws in some countries already provide for the protection of industrial trade secrets;
- ◆ **inconsistency across industries and fields**—industries and fields vary considerably in their propensity to patent inventions, and consequently, it is not advisable to compare patenting rates among different industries or fields (Scherer 1992); and
- ◆ **inconsistency in quality**—the importance of patented inventions can vary considerably (although patent citation rates, discussed later in this section as well as in chapter 5, are one method for dealing with this question of varying quality).

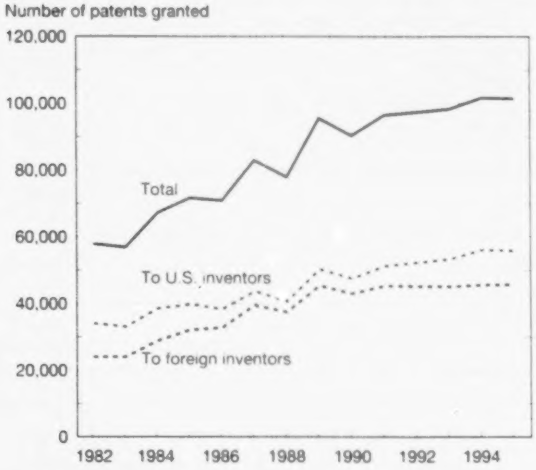
Despite these and other limitations, patents provide a unique source of information on inventive activities.

[13] About 3.3 percent of patents granted to U.S. inventors in 1995 were owned by U.S. universities and colleges. The U.S. Patent and Trademark Office counts these as being owned by corporations. For further discussion of academic patenting, see chapter 5, "Patents Awarded to U.S. Universities."

[14] Over the past 15 years, corporate-owned patents accounted for between 74 and 79 percent of total U.S.-owned patents.

After business entities, individuals are the next largest group of U.S.-origin patent owners. Prior to 1982, individuals owned, on average, 24 percent of all patents granted.[15] Their share has fluctuated between 23 and 27 percent since then. In 1995, the 23 percent share accounted for by individuals matched similar period lows in 1994. The federal share of patents averaged 3.4 percent of the total during the period 1963-82; thereafter, U.S. Government-owned patents as a share of total U.S.-origin patents declined.[16] U.S. Government-owned patents were encouraged by legislation enacted during the 1980s, which called for U.S. agencies to establish new programs and increase incentives to their scientists, engineers, and technicians that would facilitate the transfer of technology developed in the course of government activities.[17] (See "Private Use of Public Science.")

Figure 6-16.
U.S. patents granted, by nationality of inventor



See appendix table 6-12. *Science & Engineering Indicators – 1998*

Top Patenting Corporations

An examination of the top patenting corporations in the United States over the past 23 years underscores the rapid technological transformation achieved by Japan over a relatively short period. In 1973, there were no Japanese companies among the top 10 patenting corporations in the United States. In 1983, there were three Japanese companies among the top 10. By 1993, Japanese companies outnumbered U.S. companies, and the most recent data show eight Japanese companies among the top 10. (See text table 6-4.) Japan's patenting now emphasizes computer technologies, television and communications technologies, and power generation technologies.

Text table 6-4.
Top patenting corporations

Company	Number of patents
In 1996	
International Business Machines Corp.	1,867
Canon Kabushiki Kaisha	1,541
Motorola Inc.	1,064
NEC	1,043
Hitachi, LTD	963
Mitsubishi Denki Kabushiki Kaisha	934
Toshiba Corporation	914
Fujitsu Limited	869
Sony Corporation	855
Matsushita Electric Industrial Co., Ltd.	841
From 1977-96	
General Electric Corp.	16,206
International Business Machines Corp.	15,205
Hitachi, LTD	14,500
Canon Kabushiki Kaisha	13,797
Toshiba Corporation	13,413
Mitsubishi Denki Kabushiki Kaisha	10,192
U.S. Philips Corporation	9,943
Eastman Kodak Company	9,729
AT&T Corporation	9,380
Motorola Inc.	9,143

SOURCE: U.S. Patent and Trademark Office, Office of Information Systems, TAF Program. *Science & Engineering Indicators – 1998*

Patents Granted to Foreign Inventors

Foreign-origin patents represent nearly half (45 percent in 1995) of all patents granted in the United States.[18] Their share rose throughout most of the 1980s before edging downward in 1989. At their peak in 1988, foreign-origin patents accounted for 48 percent of total U.S. patents. Since then, with U.S. inventor patenting increasing faster than foreign inventor patenting, the foreign inventor share has declined several percentage points. (See appendix table 6-12.)

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[15] Prior to 1982, data are provided as a total for the period 1963-82.

[16] Federal inventors frequently obtain a statutory invention registration (SIR) rather than a patent. An SIR is not ordinarily subject to examination, and it costs less to obtain than a patent. Also, an SIR gives the holder the right to use the invention but does not prevent others from selling or using it as well.

[17] The Stevenson-Wydler Technology Innovation Act of 1980 made the transfer of federally owned or originated technology to state and local governments and to the private sector a national policy and the duty of government laboratories. The act was amended by the Federal Technology Transfer Act of 1986 to provide additional incentives for the transfer and commercialization of federally developed technologies. Later, Executive Order 12591 of April 1987 ordered executive departments and agencies to encourage and facilitate collaborations among federal laboratories, state and local governments, universities, and the private sector—particularly small business—in order to aid technology transfer to the marketplace. In 1996, Congress strengthened private sector rights to intellectual property resulting from these partnerships.

[18] Corporations account for about 80 percent of all foreign-owned U.S. patents.

Private Use of Public Science

Industry makes good use of public science, according to an analysis of more than 100,000 patent-to-science references conducted by CHI Research, Inc. (see Narin, Hamilton, and Olivastro 1997.) This study showed that 73 percent of the references to scientific publications listed as "prior art" on the front pages of U.S. patents were to public science—i.e., authored at academic, governmental, and other public institutions. (See text table 6-5.) The public science cited in these references was at the *basic* end of the research spectrum and was "...published in influential journals, authored at top-flight research universities and laboratories, was relatively recent, and heavily supported by NIH [the National Institutes of Health], NSF [the National Science Foundation], and other public agencies" (Narin, Hamilton, and Olivastro 1997). The institutions performing publicly funded research typically produce 90 percent of the articles that appear in the main influential scientific and technical journals. Nevertheless, that so much of it so quickly contributes to private sector technological breakthroughs is an important indicator of the potential economic impact of publicly funded research.

The analysis also found that the number of references to public science had nearly tripled over a recent six-year period (from 1987-88 to 1993-94), suggesting that the linkage between patented technologies and contemporary public science is growing. The availability of better electronic search tools to inventors and patent examiners in the more recent period might help to explain this trend, but researchers do not credit it alone with the tripling of science citations on U.S. patents.

The study concludes that there are strong linkages between contemporary public science and technological breakthroughs patented in the United States, and that these linkages are becoming stronger. These findings are consistent with other indicators of increased linkages and collaborations of industry with academia and national labs. (See chapters 4 and 5.)

Text table 6-5.
Number of citations from 1993-94 U.S. patents to top 15 author institutions

Biomedical papers		Chemistry papers		Physics papers		Engineering & technology papers	
Harvard University	2,506	MIT	171	Bell Labs	854	Bell Labs	471
National Cancer Institute	1,279	University of Texas at Austin	171	IBM Corp.	566	IBM Corp.	428
Veterans Administration	1,033	Harvard University	160	Stanford University	300	University of California–Berkeley	189
University of California–San Francisco	930	DuPont Co.	142	Bellcore	174	MIT	179
Stanford University	920	University of California–Berkeley	139	U.S. Naval Research Lab	167	Stanford University	162
University of Washington	845	Bell Labs	130	Lincoln Labs	150	General Electric Co.	111
MIT	756	IBM Corp.	122	MIT	133	Texas Instruments Inc.	96
Scripps Clinic & Research Foundation	690	Merck & Co. Inc.	102	University of Illinois	120	U.S. Naval Research Lab	88
University of California–Los Angeles	642	Cornell University	96	University of California–Santa Barbara	110	North Carolina State University	84
Massachusetts General Hospital	625	Texas A&M University	95	Cornell University	106	Bellcore	78
Johns Hopkins University	610	Pennsylvania State University	89	University of California–Berkeley	100	Xerox Corp.	69
Washington University	588	University of Wisconsin	87	Xerox Corp.	95	University of Illinois	64
University of California–San Diego	534	Purdue University	83	University of Pennsylvania	93	Pennsylvania State University	60
University of Pennsylvania	517	University of Illinois	83	North Carolina State University	90	University of California–Los Angeles	59
Merck & Co., Inc.	484	University of California–Los Angeles	79	Caltech	87	Lincoln Labs	57

SOURCE: Narin, Hamilton, and Olivastro 1997

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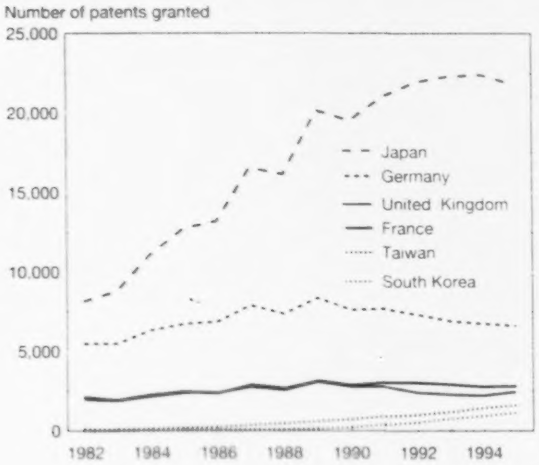
Foreign patenting in the United States is highly concentrated by country of origin. In 1995, two countries—Japan and Germany—accounted for over 60 percent of U.S. patents granted to foreign inventors. The top five countries—Japan, Germany, France, the United Kingdom, and Canada—accounted for 80 percent. (See figure 6-17.) These data show a slowdown in U.S. patenting activity by inventors from these five countries. From 1982 to 1992, U.S. patenting activity by inventors from these five countries nearly doubled, peaking in 1992 at nearly 37,000 U.S. patents. Patenting by Japanese and French inventors was especially strong during this period.

Since then, patenting by inventors from the leading industrialized countries has leveled off and has even begun to decline in some instances.[19] France, Germany, and Japan were each awarded fewer U.S. patents in 1995 than in 1992. The United Kingdom and Canada increased their patenting, but only slightly. Other countries, particularly Asian countries outside Japan, have stepped up their patenting activity in the United States and are showing themselves to be strong inventors of new technologies. This is especially true for Taiwan and South Korea. Before 1982 (data are available starting in 1963), Taiwan was awarded just 316 U.S. patents. Between 1982 and 1995, Taiwan was awarded nearly 9,000 U.S. patents. U.S. patenting activity by inventors from South Korea shows a similar growth pattern. Before 1982, South Korea was awarded just 102 U.S. patents; since then, more than 4,500 new patents have been awarded. Inventors from China and Hong Kong also rapidly increased their patenting in the United States since 1982. Even so, when the number of U.S. patents awarded to China and Hong Kong in 1995 are combined, they represent less than one-tenth the number awarded to Taiwan in that year.

Figure 6-17.
U.S. patents granted to foreign inventors, by nationality of inventor



See appendix table 6-12 *Science & Engineering Indicators – 1998*

Technical Fields Favored by Foreign Inventors

A country's distribution of patents by technical area has proved to be a reliable indicator of a nation's technological strengths, as well as an indicator of direction in product development. This section compares and discusses the various key technical fields favored by inventors in the world's three leading economies—the United States, Japan, and Germany—and in two newly industrialized economies—Taiwan and South Korea.[20]

Fields Favored by U.S., Japanese, and German Inventors

While U.S. patent activity spans a wide spectrum of technology and new product areas, U.S. corporations' patenting shows a particular emphasis on several of the technology areas that are expected to play an important role in future economic growth (U.S. OSTP 1997). In 1995, corporate patent activity reflected U.S. technological strengths in developing new medical and surgical devices, electronics, telecommunications, advanced materials, and biotechnology. (See text table 6-6 and appendix table 6-13.)

The 1995 patent data continue to show Japanese inventors emphasizing technology classes associated with photography, photocopying, and consumer electronics industries. (See appendix table 6-14.) What is also evident in 1995 is the broader range of U.S. patents awarded to Japanese inventors in information technology. From improved information storage technology for computers to visual display systems, Japanese inventions are earning U.S. patents in areas that aid the processing, storage, and transmission of information.

German inventors continue to develop new products and processes in technology areas associated with heavy manufacturing industries in which that country has traditionally maintained a strong presence. The 1995 U.S. patent activity index shows a German emphasis on motor vehicles, printing, new chemistry and advanced materials, and material handling equipment patent classes. (See appendix table 6-15.) German inventors have also stepped up their patent activity in some newer technology areas, such as biotechnology and opto-electronics.

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[19] Some of the decline in U.S. patenting by inventors from the leading industrialized nations may be attributed to the move toward European unification, which has encouraged wider patenting within Europe.

[20] Information in this section is based on the U.S. Patent and Trademark Office's classification system, which divides patents into approximately 370 active classes. With this system, patent activity for U.S. and foreign inventors in recent years can be compared by developing an activity index. For any year, the activity index is the proportion of patents in a particular class granted to inventors in a specific country divided by the proportion of all patents granted to inventors in that country. Because U.S. patenting data reflect a much larger share of patenting by individuals without corporate or government affiliation than do data on foreign patenting, only patents granted to corporations are used to construct the U.S. patenting activity indices.

Fields Favored by Two Newly Industrialized Economies

Patent activity in the United States by inventors from newly industrialized economies can be seen as an indicator of these economies' technological development and as a leading indicator of U.S. product markets likely to see increased competition.

As recently as 1980, *Taiwan's* U.S. patent activity was primarily in the area of toys and other amusement devices. By the 1990s, Taiwan was active in such areas as communications technology, semiconductor manufacturing processes, and internal combustion engines (see NSB 1991). The latest available data (1995) show that inventors from Taiwan have continued to patent heavily in communications technologies and processes used in the manufacture of semiconductor devices; data also show heavy activity in computer storage and display devices, advanced materials, and transistors. (See text table 6-7 and appendix table 6-16.) Ten years earlier, inventors from Taiwan received no patents in any of these technology classes.

U.S. patenting by *South Korean* inventors has also shown rapid technological development. The 1995 data show that Korean inventors are patenting heavily in television technologies, electrical products, and advanced materials. (See text table 6-7 and appendix table 6-17.) South Korea's patenting has also expanded into a broader array of computer technologies that include devices for dynamic and static information storage, data generation and conversion, error detection, and display systems.

Both South Korea and Taiwan are already major suppliers of computers and peripherals to the United States. The recent patenting data show that their scientists and engineers are continuing to develop new technologies and improve existing technologies. It is likely that these new inventions will enhance these economies' competitiveness in the United States and in global markets.

Patenting Outside the United States

In most parts of the world, foreign inventors account for a much larger share of total patent activity than in the United States. When foreign patent activity in the United States is compared with that in 15 other important countries in 1985, 1990, and 1995, only Russia and Japan had less foreign patent activity. (See figure 6-18 and appendix table 6-18.)

What is often obscured by the rising trends in foreign-origin patents in the United States is the success and widespread activity of U.S. inventors in patenting their inventions around the world. U.S. inventors lead all other foreign

Text table 6-6.
Top 15 most emphasized U.S. patent classes for inventors from the United States, Japan, and Germany: 1995

	United States	Japan	Germany
1.	Wells	Dynamic information storage or retrieval	Fluid-pressure brake systems
2.	Surgery (class 606)	Photography	Printing
3.	Surgery (class 604)	Music	Brakes
4.	Surgery: light, thermal, and electrical applications	Photocopying	Conveyors: power driven
5.	Chemistry of hydrocarbons	Facsimile or television recording	Organic compounds (class 548)
6.	Special receptacle or package	Typewriting machines	Metal deforming
7.	Surgery (class 128)	Static information storage and retrieval	Organic compounds (class 546)
8.	Receptacles	Dynamic magnetic information storage or retrieval	Internal-combustion engines
9.	Supports	Active solid state devices	Sheet feeding or delivering
10.	Cryptography	Radiation imagery chemistry: process, composition	X-ray or Gamma ray devices
11.	Static structures (e.g., buildings)	Incremental printing	Plastic or earthenware shaping apparatus
12.	Processes, compositions for food or edible material	Optics: systems and element	Organic compounds (class 568)
13.	Amusement devices: games	Electrical generator	Organic compounds (class 549)
14.	Cleaning and liquid contact with solids	Television	Machine element or mechanism
15.	Chemistry: analytical and immunological testing	Metal treatment	Synthetic resins or natural rubbers (class 528)

See appendix tables 6-13, 6-14, and 6-15.

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Text table 6-7.
Top 15 most emphasized U.S. patent classes for inventors from South Korea and Taiwan: 1995

	South Korea	Taiwan
1.	Electric lamp and discharge devices	Semiconductor device manufacturing process
2.	Semiconductor device manufacturing process	Selective visual display systems
3.	Television	Machine element
4.	Facsimile or television recording	Chairs and seats
5.	Dynamic information storage and retrieval	Electric lamp and discharge devices
6.	Dynamic magnetic information storage or retrieval	Active solid state devices (e.g., transistors)
7.	Static information storage and retrieval	Electrical nonlinear devices
8.	Winding, tensioning, or guiding	Illumination
9.	Electric heating	Plastic or earthenware shaping devices
10.	Error detection/correction	Supports
11.	Electric lamp and discharge devices, systems	Electricity, circuit makers and breakers
12.	Electricity: motive power systems	Wave transmission lines and networks
13.	Electrical audio signal processing systems	Land vehicles
14.	Active solid state devices (e.g., transistors)	Music
15.	Coded data generation or conversion	Static information storage and retrieval

See appendix tables 6-16 and 6-17.

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inventors not just in countries neighboring the United States (Canada and Mexico), but also in distant markets such as Japan, Brazil, Hong Kong, India, Malaysia, and Thailand. (See figure 6-19.) Japanese inventors edge out Americans in Germany and the United Kingdom, and dominate foreign patenting in South Korea. German inventors lead all foreign inventors in France, Italy, and Russia; they are also quite active in many of the other countries examined.

International Patenting Trends for Three Important Technologies

This section explores the relative strength of America's technological position by examining international patenting patterns in three important technology areas: advanced manufacturing, biotechnology, and advanced materials.[21] To facilitate the patent search and analysis, these broad technology areas were each represented by a narrower subfield: robot technology as a proxy for advanced manufacturing, genetic engineering for biotechnology, and advanced ceramics for advanced materials.[22] To ensure maximum comparability of data, this analysis is built around the concept of a "patent family"—i.e., all the patent documents published in different countries associated with a single invention. (See "International Patent Families as a Basis for Comparison.")

International Patent Families as a Basis for Comparison

A patent family consists of all the patent documents associated with a single invention that are published in different countries. The first application filed anywhere in the world is the priority application: it is assumed that the country in which the priority application was filed is the country in which the invention was developed. Similarly, the priority year is the year the priority application was filed. The basic patent is the first patent or patent application published in any of the roughly 40 countries covered in the database used in this section. This database, the Derwent World Patents Index Latest, covers basic patents published from 1981 to the present.

National patent systems, such as Japan's, that encourage large numbers of domestic patent applications skew counts of patent families over time as an indicator of technological activity. To eliminate this bias, international patent families are used as a basis of comparison. An international patent family is created when patent protection is sought in at least one other country besides that in which the earliest priority application was filed.

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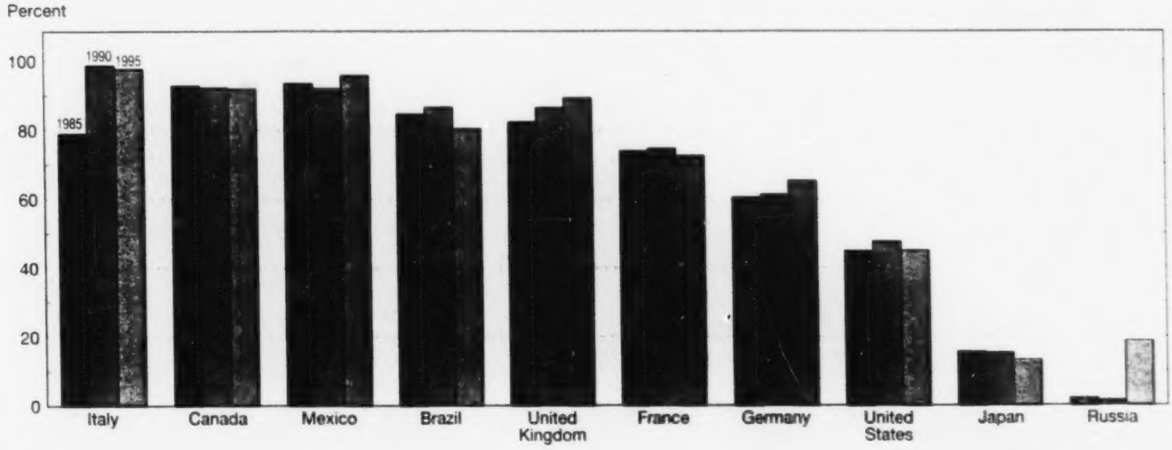
[21] Data in this section are drawn from a database containing patent records from about 40 major patenting countries, which facilitates a more comprehensive assessment of U.S. technological position vis-à-vis other national competitors. These data were developed under contract for the National Science Foundation by Mogee Research & Analysis Associates; they were extracted from the Derwent World Patents Index database published by Derwent Publications Ltd. The technology areas selected for this study met several criteria:

- Each technology appeared on the lists of "critical" technologies considered/deemed important to future U.S. economic competitiveness or national security (see Mogee 1991 and U.S. OSTP 1995).
- Each technology is characterized by the output of patentable products or processes.
- Each technology could be defined sufficiently to permit construction of accurate patent search strategies.
- Each technology yielded a sufficient population for statistical analysis.

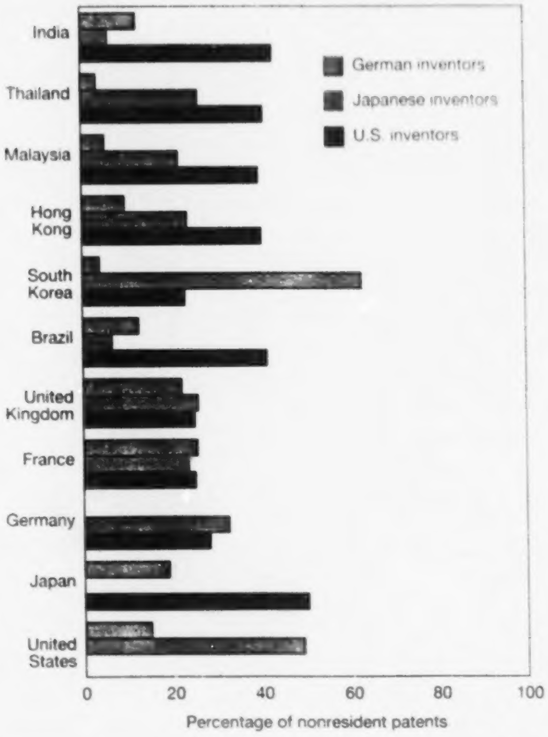
[22] These subfields were identified based on a review of recent critical technologies reports and extensive consultation with National Science Foundation staff and experts in the technologies to determine representative subfields.

Figure 6-18.
Share of total patents awarded to nonresident inventors



See appendix tables 6-12 and 6-18. *Science & Engineering Indicators – 1998*

Figure 6-19.
Patents granted to nonresident inventors: 1994



See appendix table 6-18. *Science & Engineering Indicators – 1998*

Three indicators are used here to compare national positions in each critical technology:

- **Trends in international inventive activity**—This indicator provides a first measure of the extent and growth of each nation's inventive activity considered important enough to be patented outside of the country of origin. These data are tabulated by priority year.
- **Highly cited inventions**—Interpatent citations are an accepted method of gauging the technological value or significance of different patents.[23] These citations, provided by the patent examiner, indicate the "prior art"—i.e., the technology in related fields of invention—that was taken into account in judging the novelty of the present invention.[24] The number of citations a patent receives from later patents can serve as an indicator of its technical importance or value. The technological significance indicator used here attempts to assess a country's contribution toward advancing the particular technology field

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[23] Carpenter, Narin, and Woolf (1981) show that technologically important U.S. patents on average receive twice as many examiner citations as does the average U.S. patent, thus helping to confirm the validity of interpatent citation as an indicator of patent quality.

[24] The citations counted are those placed on European Patent Office (EPO) patents by EPO examiners. EPO citations are believed to be a less biased and broader source of citations than those of the U.S. Patent and Trademark Office. See Claus and Higham (1982).

by determining the number of highly cited international patent families from each priority country.[25]

- **International patent family size**—Given the significant costs associated with obtaining patent protection in multiple countries, it can be assumed that the number of countries in which protection has been sought may be indicative of an invention's commercial potential. An indicator attempting to measure the commercial potential of a nation's patented inventions is calculated in two steps: first, by computing mean family size for international patent families by priority country, and then by adjusting the mean family size for the size of the national markets in which protection is being sought.[26]

In each technology area, U.S. inventive activity is examined for the 1990-94 period, alongside that of five other countries: Japan, Germany, France, the United Kingdom, and South Korea.

Robot Technology

As used here, robot technology covers program-controlled manipulators—e.g., the manipulator, program control, gripping heads, joints, arm sensors, safety devices, and accessories—and excludes non-program-controlled manipulators, prosthetic devices, and toy robots.

International Patenting Activity. During the first half of the 1990s, 1,719 international patent families were formed in robotics, with priority applications in the six countries examined. (See figure 6-20.) Patenting activity in the six-country group accounts for about three-quarters of all families in this technology area.

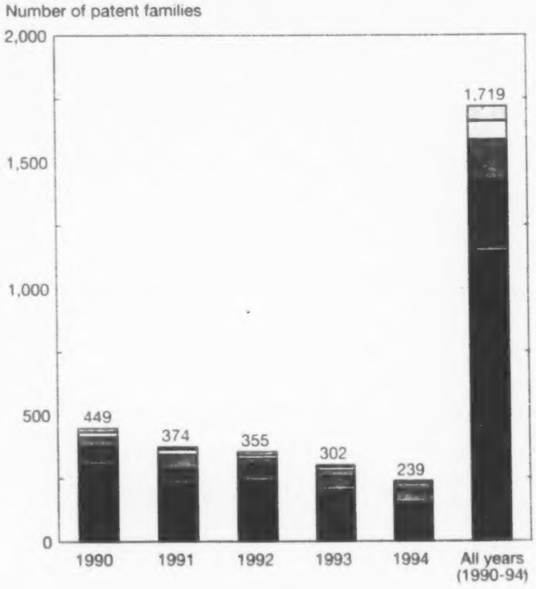
The conventional perception of Japan as an innovator in the area of advanced manufacturing techniques is reinforced by the large number of robot inventions originating in Japan. Japan led all other countries studied in the total number of international patent families in robot technology created during the 1990-94 period. Japanese inventors held 43 percent of the total number of international patent families formed by the six countries included in the study, followed by the United States (24 percent), Germany (16 percent), France (9 percent), the United Kingdom (4 percent), and South Korea (3 percent).

Japan ranks number one in patent activity when the entire five-year period is considered; however, this activity declined rapidly after 1992. At about the same time, U.S. activity picked up; in 1994, the United States led Japan in the number of international robot technology patent families formed.

Although South Korea's share of international patent families was the lowest overall, its share was comparable in size to that of the larger and more advanced economy of the United Kingdom (3.4 percent for Korea versus 4.2 percent for the United Kingdom). Given its newly industrialized economy status, South Korea's overall international inventive activity in this technology area is impressive—especially when the data show that South Korea's patenting activity in this technology area equaled that of the United Kingdom in 1994.

Highly Cited Robot Inventions.[27] On this indicator, the United States led all countries—and by a wide margin—with 55.6 percent of all highly cited robot technology international families generated during the 1990-94 period (10 of 18). Japan (with 33.3 percent of the highly cited patents) and Germany (with 11.1 percent) trailed distantly. (See text table 6-8.) The United Kingdom, France, and South Korea did not have any international robot families in the highly cited group.

Figure 6-20.
Robot technology: Number of international patent families, by priority year and country



		1990	1991	1992	1993	1994	All years (1990-94)
South Korea	☐	15	10	14	9	11	59
United Kingdom	☐	18	19	12	12	11	72
France	▨	39	56	22	25	20	162
Germany	■	68	56	64	50	40	278
United States	■	112	59	66	87	87	411
Japan	■	197	174	177	119	70	737

SOURCE: Derwent World Patents Index Database (London: Derwent Publications Ltd., 1996), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

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[25] "Highly cited" here means the top 1 percent of international families in terms of the number of citations received. To adjust for the advantage countries with large numbers of international families would have on this indicator, a country's share of highly cited patents are divided by its share of total patent families.

[26] Operationally, this calculation involves counting the number of countries in a family in which a patent publication (i.e., a published patent application or an issued patent) exists. Patents in each family are weighted by an index based on the GDP in purchasing power parities at current U.S. dollars of the patent country. The index runs from 0 to 1.00, and U.S. GDP is set at 1.00.

[27] This indicator included all families with priority application dates from 1990 to 1994 with eight or more citations.

Text table 6-8.

Robot technology: International patent families, highly cited patent families, and citation ratios, by priority country: 1990-94

Priority country	Number of international families	Number of highly cited international families[a]	Country share of total (percent)	Country share of highly cited (percent)	Citation ratio[b]
Total	1,719	18.0	100.0	100.0	1.0
United States	411	10.0	23.9	55.6	2.3
Japan	737	6.0	42.9	33.3	0.8
Germany	278	2.0	16.2	11.1	0.7
United Kingdom	162	0.0	9.4	0.0	0.0
France	72	0.0	4.2	0.0	0.0
South Korea	59	0.0	3.4	0.0	0.0

[a] An international patent family was considered highly cited if the number of citations it received ranked it within the top 1 percent compared with all other robot technology international patent families.

[b] A citation ratio of greater than 1.0 indicates that a country has a higher share of highly cited international patent families than would be expected based on its share of total families.

SOURCE: Derwent World Patents Index Database (London: Derwent Publications Ltd., 1996), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

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Only the United States had more highly cited international patent families than would be expected—2.3 times—based on its level of activity (i.e., based on the total number of U.S. international robot technology families). None of the other countries studied produced the expected number of highly cited inventions. Specifically, Japan produced only about 80 percent of what might be expected based on the number of inventions it produced during this period, and Germany produced only about 70 percent of what was expected. Again, France, the United Kingdom, and South Korea—with nearly 300 international robot patent families among them—had no highly cited robot inventions during this period.

The United States thus appears to have contributed a disproportionate number of important robot inventions relative to its level of inventive activity. This circumstance also may suggest that even though Japan had a higher number of international robot inventions, U.S. inventions were more technologically important.

Mean International Patent Family Size. This indicator attempts to measure the perceived economic potential of a robot invention by calculating, for each international patent family, the number of countries in which patent protection is being sought, adjusted for market size. When mean international patent family size is calculated for each country's robot technologies, there is not as much separation in the scores as might be expected. (See text table 6-9.) U.S. inventions received the highest score and therefore have the highest level of perceived commercial value based on this measure. South Korean inventions received the lowest score. Since most inventions are first patented in the country in which the inventor resides, U.S. inventions have an advantage in this indicator due to the large size of the U.S. economy.[28] But European inventions also have the advantage of many commercial, locational, and historical ties that facilitate multiple-country patenting. Furthermore, the move toward European unification has encouraged wider patenting within Europe. Still, U.S. inventions scored slightly higher on average than did European robot inventions. Japan's robot inventions also scored well on this indicator, bolstered by the tendency of Japanese inventors to seek patent protection in large economies such as the United States and Germany (79 and 60 percent, respectively). South Korea scored remarkably well, but it too sought patent protection for most of its robot inventions in large markets like the United States (64 percent) and Japan (41 percent).

Genetic Engineering

For this study, genetic engineering is defined as recombinant DNA (rDNA) technology. It includes processes for isolation, preparation, or purification of DNA or RNA; DNA or RNA fragments and modified forms thereof; the introduction of foreign genetic material using vectors; vectors; use of hosts; and expression.[29] As used here, genetic engineering does not include monoclonal antibody technology.

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[28] Because of its market size, the United States attracts most commercially important inventions; for this reason, data on U.S. patenting are often used to compare international inventiveness. To overcome differences in national patent systems, the European Commission chose U.S. patent data as a basis for comparing technological output performance of industrial R&D for member countries and stated, "The US is undoubtedly still the most important technological 'market' attracting all major inventions from across the world" (European Commission 1994).

[29] The trends discussed for genetic engineering technology are based on all genetic engineering international families in the Derwent World Patents Index Latest database, with priority applications in the six countries under study and basic patent publications from 1991 to 1997. These six countries accounted for over 85 percent of the total genetic engineering patent families.

Text table 6-9.

Robot technology: Number of international patent families and average international family size: 1990-94

Priority country	Number of families	Average international family size	Adjusted average international family size[a]
United States	411	7.9	1.6
France	162	8.8	1.4
Japan	737	4.6	1.3
United Kingdom	72	10.1	1.3
Germany	278	8.3	1.2
South Korea	59	2.1	1.0

NOTE: Patent family size is determined by the number of countries for which patent protection is sought for a single invention.

[a] Patent family data weighted by an index based on gross domestic product measured in purchasing power parities at current U.S. dollars of the patent country. This weighting adjusts family size for the size of the national markets in which protection is being sought in an effort to better reflect the commercial potential of the invention.

SOURCE: Derwent World Patents Index Database (London: Derwent Publications Ltd., 1996), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

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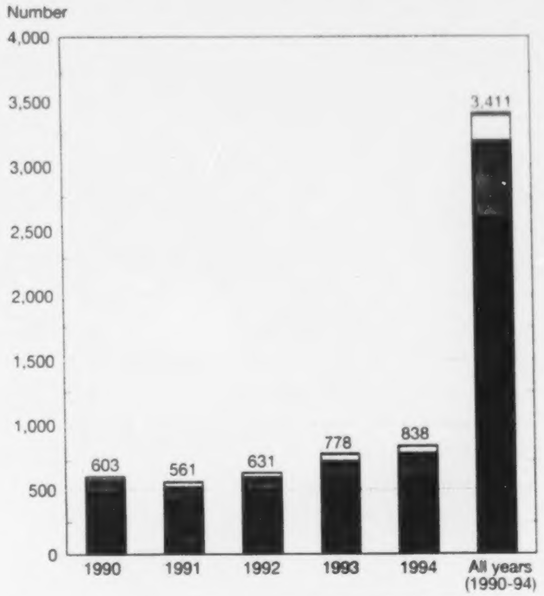
Figure 6-21.

Genetic engineering: Number of international patent families, by priority year and country



		1990	1991	1992	1993	1994	All years (1990-94)
South Korea	▨	2	4	3	8	4	21
France	□	22	36	32	52	54	196
Germany	■	48	41	35	45	75	244
United Kingdom	■	46	50	58	85	105	344
Japan	■	100	67	94	89	91	441
United States	■	385	363	409	499	509	2,165

SOURCE: Derwent World Patents Index Database (London: Derwent Publications Ltd., 1996), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

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International Patenting Activity. If the decade of the 1980s generally introduced genetically engineered products to the global marketplace, then the 1990s may become the decade when genetically engineered products come of age. Although slow compared to patenting in the previous decade, the number of international patent families grew steadily from 1991 to 1994, with the largest jump recorded in 1993. (See figure 6-21.) The United States is widely considered the global leader in the biotechnology field, and these data support that perception. The United States is the priority country (location of first patent application) for 63 percent of the internationally patented inventions created during the 1990-94 period: Japan follows with 13 percent, the United Kingdom with 10 percent, and Germany with 7 percent.

When the total number of foreign applications associated with each country's genetic engineering technology is considered, the United States continues to lead all other countries by a wide margin. The United States had more foreign patents than the other five countries combined, accounting for almost 64 percent of the nearly 42,000 foreign patents. The rankings and shares for the other five countries remain the same.

Highly Cited Genetic Engineering Inventions.[30] Out of the 3,411 international patent families in genetic engineering formed by the six countries during the 1990-94 period, only 39 were considered highly cited inventions. The United States, with about 63 percent of the total international patent families recorded during the period, also had the largest proportion of highly cited international patent families—59 percent. (See text table 6-10.) Japan, with 13 percent of the total families, had just 10 percent that were highly cited. The United States, Japan, Germany, and South Korea all produced fewer highly cited patents than expected based on their shares of patent families associated with this technology. The United Kingdom produced the expected number of highly cited inventions based on its share of the total genetic engineering inventions patented internationally (citation ratio equal to 1.0). The only country that exceeded expectations on this indicator was France. France, with far fewer patent families overall than the other countries examined, produced more than three times the number of important or highly cited patents as expected based on its level of activity.

Based on this indicator, the United States leads the other countries in terms of the volume of important (highly cited) genetic engineering inventions it produced during the period

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[30] Operationally, this indicator included all international patent families with priority application dates from 1990 to 1994 with four or more citations.

Text table 6-10.

Genetic engineering: International patent families, highly cited patent families, and citation ratios, by priority country: 1990-94

Priority country	Number of international families	Number of highly cited international families[a]	Country share of total (percent)	Country share of highly cited (percent)	Citation ratio[b]
Total	3,411	39.0	100.0	100.0	1.0
United States	2,165	23.0	63.5	59.0	0.9
France	196	7.0	5.7	17.9	3.1
United Kingdom	344	4.0	10.1	10.3	1.0
Japan	441	4.0	12.9	10.3	0.8
Germany	244	1.0	7.2	2.6	0.4
South Korea	21	0.0	0.6	0.0	0.0

[a] An international patent family was considered highly cited if the number of citations it received ranked it within the top 1 percent compared with all other genetic engineering technology international patent families.

[b] A citation ratio of greater than 1.0 indicates that a country has a higher share of highly cited international patent families than would be expected based on its share of total international families.

SOURCE: Derwent World Patents Index Database (London: Derwent Publications Ltd., 1996), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

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examined. While it fell slightly short (citation ratio of 0.9) of what might be expected given its share of overall patenting in this technology, the total number of highly cited patents produced by the United States in this important technology area is nevertheless noteworthy.

Mean International Patent Family Size. Patented genetic engineering inventions developed in Japan and Germany appear to be the most commercially valuable, on average, based on this measure, although the scores for each of the countries are similar. (See text table 6-11.) Japan has sought patent protection in 11 countries whose combined economies are equivalent to 1.6 times that of the United States (based on GDP); German-origin inventions average 14.7 countries with a combined GDP equal to 1.5 times that of the United States. Patented genetic engineering inventions originating in the United States rank third in perceived commercial exploitation potential. Inventions originating in France, South Korea, and the United Kingdom all trailed the United States based on this measure.

Text table 6-11.

Genetic engineering: Number of international patent families and average international family size: 1990-94

Priority country	Number of families	Average international family size	Adjusted average international family size[a]
Japan	441	11.3	1.6
Germany	244	14.7	1.5
United States	2,165	12.8	1.4
France	196	14.9	1.3
South Korea	21	10.0	1.3
United Kingdom	344	12.4	1.0

NOTE: Patent family size is determined by the number of countries for which patent protection is sought for a single invention.

[a] Patent family data weighted by an index based on gross domestic product measured in purchasing power parities at current U.S. dollars of the patent country. This weighting adjusts family size for the size of the national markets in which protection is being sought in an effort to better reflect the commercial potential of the invention.

SOURCE: Derwent World Patents Index Database (London: Derwent Publications Ltd., 1996), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

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Advanced Ceramics

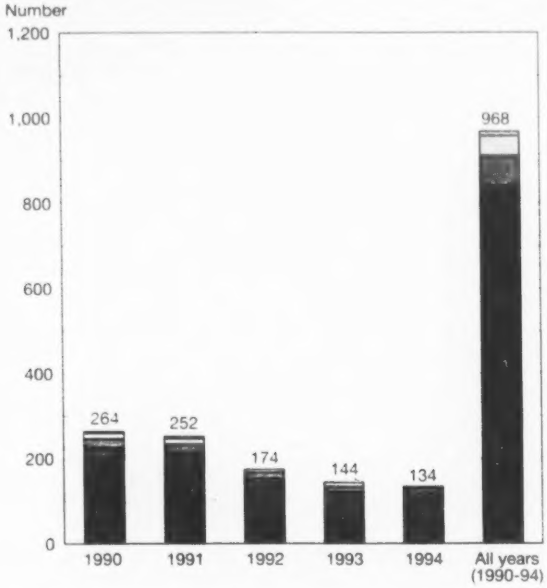
National technological positions in the broad field of advanced materials have been assessed through an examination of international patenting activity in advanced ceramics. For this study, advanced ceramics are defined as ceramics (i.e., inorganic, nonmetallic solids) with compositions not usually found in traditional ceramics. These compositions include oxides, carbides, nitrides, and borides, as well as aluminate, titanate, zirconia, and modified silicates. The six countries analyzed represent approximately 90 percent of total international patent family activity by all countries in this technology.

International Patenting Activity. During the 1990-94 period, these six countries generated a total of 968 international patent families in the field of advanced ceramics. Annual formation of international patent families varied from a high of 264 in 1990 to 134 in 1994, which is the last priority year for which complete data are available.

Japan and the United States lead all other nations in the formation of international patent families involving advanced ceramics technology. Together they accounted for over 70 percent of the total formed in the five-year period examined. (See figure 6-22.) Japan held 39 percent of the total families formed (with 381 international families) over the period studied; the United States held 32 percent (with 310 international families). Germany, France, and the United Kingdom trailed with 16, 7, and 5 percent of the total, respectively. South Korea held 1 percent of the international patent families in this technology.

When the total number of foreign applications associated with each country's advanced ceramics technology is considered, the United States and Japan switch places, with the United States taking the lead in terms of total number of foreign patents sought for advanced ceramics technology. Out of a total of 7,025 advanced ceramics foreign patents generated from priority applications filed by the six countries during the 1990-94 period, the United States generated 40 percent (2,811 patents); Japan generated 24 percent (1,669 patents).

Figure 6-22.
Advanced ceramics technology: Number of international patent families, by priority year and country



		1990	1991	1992	1993	1994	All years (1990-94)
South Korea	☐	4	5	0	0	1	10
United Kingdom	☐	13	13	7	10	4	47
France	■	19	16	13	12	9	69
Germany	■	33	45	33	19	21	151
United States	■	87	71	60	43	49	310
Japan	■	108	102	61	60	50	381

SOURCE: Derwent World Patents Index Database (London: Derwent Publications Ltd., 1996), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

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Highly Cited Advanced Ceramics Inventions.[31] Out of the 968 international patent families formed during the 1990-94 period, only 23 were highly cited. Japan generated the greatest number of international patent families in this technology area during the same period, but the United States had the greatest number of highly cited inventions with 15 (or 65 percent of all highly cited international patent families). (See text table 6-12.) Japan was second with four. When each country's number of highly cited international patent families is adjusted to account for its overall volume of international patenting in this technology (citation ratio), the United States again leads all six nations. The United States had a citation ratio of 2.0—that is, twice as many highly cited international patent families as would be expected given its share of total families during the period. Japan's citation ratio, 0.4, suggests that the four highly cited international families it produced during this period were below expectations, given the total number of international patent families the country generated. The United Kingdom had only two highly cited international families, but exceeded expectations in this indicator with a citation ratio of 1.8. France and Germany each had one highly cited international patent family, falling below expectations given their share of total families in this technology.

Mean International Patent Family Size. The advanced ceramics inventions with the highest perceived foreign market potential, on average, were produced in France; these were closely followed by those produced in the United States. (See text table 6-13.) The United States also had the second largest number of international patent families for the period examined. Japan, the most prolific inventor of world-class advanced ceramics technologies during the 1990-94 period, trailed the United States and the large European nations in terms of average commercial potential for each invention. South Korea also trailed the leaders, but still made an impressive showing in this technology area, providing yet another indication of its progress in developing science-based technologies (see NSB 1993, p. 185).

Taken together, these indicators suggest strong U.S. inventive activity in advanced ceramics technology. While producing the second largest number of international patent families in this category during the period studied, U.S. inventions were the most highly cited and had nearly the highest average commercial potential when compared with inventive activity in the other five nations.

Summary

Based on this examination of international patenting, the U.S. S&T enterprise is producing inventions in important technologies that are able to be patented around the world. The U.S. lead in genetic engineering was most evident from this collection of international patenting indicators, but U.S. inventors also made a strong showing in robot technologies, especially in 1994.

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[31] Operationally, this indicator included all families with priority application dates from 1990 to 1994 with four or more citations.

Text table 6-12.
Advanced ceramics technology: International patent families, highly cited patent families, and citation ratios, by priority country: 1990-94

Priority country	Number of international families	Number of highly cited international families[a]	Country share of total (percent)	Country share of highly cited (percent)	Citation ratio[b]
Total	968	23.0	100.0	100.0	1.0
United States	310	15.0	32.0	65.2	2.0
Japan	381	4.0	39.4	17.4	0.4
Germany	151	1.0	15.6	4.3	0.3
France	69	1.0	7.1	4.3	0.6
United Kingdom	47	2.0	4.9	8.7	1.8
South Korea	10	0.0	1.0	0.0	0.0

[a] An international patent family was considered highly cited if the number of citations it received ranked it within the top 1 percent compared with all other advanced ceramics technology international patent families.

[b] A citation ratio of greater than 1.0 indicates that a country has a higher share of highly cited international patent families than would be expected based on its share of total international families.

SOURCE: Derwent World Patents Index Database (London: Derwent Publications Ltd., 1996), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

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Text table 6-13.
Advanced ceramics technology: Number of international patent families and average international family size: 1990-94

Priority country	Number of families	Average international family size	Adjusted average international family size[a]
France	69	11.2	1.9
United States	310	9.8	1.8
United Kingdom	47	11.6	1.7
Germany	151	9.7	1.7
Japan	381	5.3	1.6
South Korea	10	3.2	1.3

NOTE: Patent family size is determined by the number of countries for which patent protection is sought for a single invention.

[a] Patent family data weighted by an index based on gross domestic product measured in purchasing power parities at current U.S. dollars of the patent country. This weighting adjusts family size for the size of the national markets in which protection is being sought in an effort to better reflect the commercial potential of the invention.

SOURCE: Derwent World Patents Index Database (London: Derwent Publications Ltd., 1996), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

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Venture Capital and High-Technology Enterprise

One of the most serious challenges to new entrepreneurs in the innovation process is capital—or the lack thereof. Venture capitalists typically make investments in small, young companies that may not have access to public or credit-oriented institutional funding. Venture capital investments can be long term and high risk, and may include hands-on involvement by the venture capitalist in the firm. Venture capital thus can aid the growth of promising small companies and facilitate the introduction of new products and technologies, and is an important source of funds used in the formation and expansion of small high-tech companies. This section examines venture capital disbursements by stage of financing and by technology area in the United States and Europe.

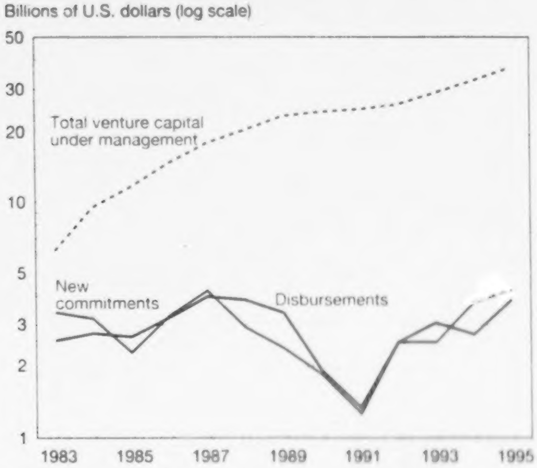
U.S. Venture Capital Industry

The pool of capital managed by venture capital firms grew dramatically during the 1980s as venture capital emerged as a truly important source of financing for small innovative firms. (See figure 6-23 and appendix table 6-19.) By 1989, the capital managed by venture capital firms totaled $23.2 billion, up from an estimated $3.0 billion in 1980. The number of venture capital firms also grew during the 1980s—from around 448 in 1983 to 670 in 1989.

In the early 1990s, the venture capital industry experienced a recession of sorts, as investor interest waned and the amount of venture capital disbursed to companies declined—especially compared to the extensive venture capital activity of the late 1980s. The number of firms managing venture capital also declined during the 1990s. But the slowdown was short-lived; investor interest picked up during 1992, and disbursements began to rise again. Both investor interest and venture capital disbursements have continued to grow through 1995. The latest data show total venture capital under management rising to $37.2 billion in 1995, up from $32.7 billion in 1994 and $28.9 billion in 1993.

The number of venture capital firms in the United States did not rebound to the peak of 1989 (670), but after several

Figure 6-23.
U.S. venture capital: Total under management, annual commitments, and disbursements



See appendix table 6-19. *Science & Engineering Indicators – 1998*

years of firm rationalization, the number rose to 610 venture capital firms in 1995 from the 591 operating in 1994. California, Massachusetts, and New York together account for nearly 65 percent of venture capital resources. The top 10 states account for over 95 percent. It appears that venture capital firms tend to cluster around locales considered to be "hotbeds" of technological activity, as well as in states where large amounts of R&D are performed.

Venture Capital Commitments and Disbursements

Several years of high returns on venture capital investments have stimulated increased investor interest. This interest soared from 1993 to 1995, with new commitments reaching $4.2 billion in 1995, the largest one-year increase in venture capital funds. Pension funds remain the single largest source for new funds, supplying nearly 40 percent of committed capital. Endowments/foundations are the next largest source, supplying 23 percent of committed capital in 1995. (See appendix table 6-20.)

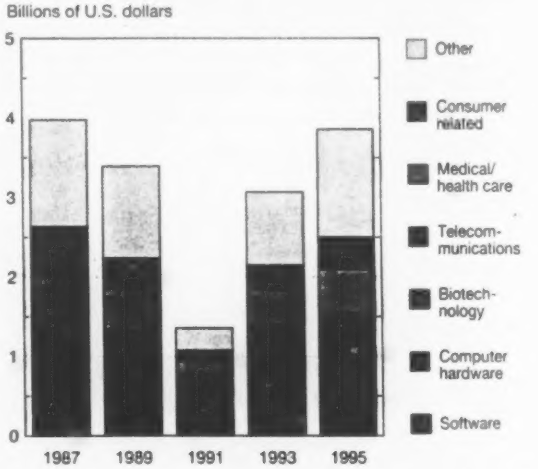
Starting in 1994, new capital raised exceeded capital disbursed by the venture capital industry, thereby creating surplus funds available for investments in new or expanding innovative firms. Thus far in the 1990s, firms producing computer software or providing computer-related services received the largest share of new disbursements. (See figure 6-24 and appendix table 6-21.) In 1991, software companies received 25 percent of all new venture capital disbursements, twice the share going to computer hardware companies and three times the share going to biotechnology companies. In 1995, software companies continued to attract the largest share of venture capital. Medical/health-care-related companies have also attracted large amounts of venture capital during the 1990s, and edged out software companies for the lead in 1994. Other industries that received substantial amounts of venture capital in 1995 were telecommunications companies and consumer-related companies (e.g., leisure products, retailing, etc.).

Venture Capital Investments by Stage of Financing

The investments made by venture capital firms may be categorized by the stage at which the financing is provided:[32]

- **Seed financing**—usually involves a small amount of capital provided to an inventor or entrepreneur to prove a concept. It may support product development but rarely is used for marketing.
- **Startup financing**—provides funds to companies for use in product development and initial marketing. This type of financing usually is provided to companies that are just getting organized or that have been in business just a short time but have not yet sold their product in the marketplace. Generally, such firms have already assembled key management, prepared a business plan, and made market studies.
- **First-stage financing**—provides funds to companies that have exhausted their initial capital and need funds to initiate commercial manufacturing and sales.
- **Expansion financing**—includes working capital for the initial expansion of a company, funds for either major

Figure 6-24.
U.S. venture capital disbursements, by industry category



See appendix table 6-21. *Science & Engineering Indicators – 1998*

growth expansion (involving plant expansion or marketing) or development of an improved product, and financing for a company expecting to go public within six months to a year.

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[32] The financing stage definitions presented here are by Venture Economics (1996), appendix C.

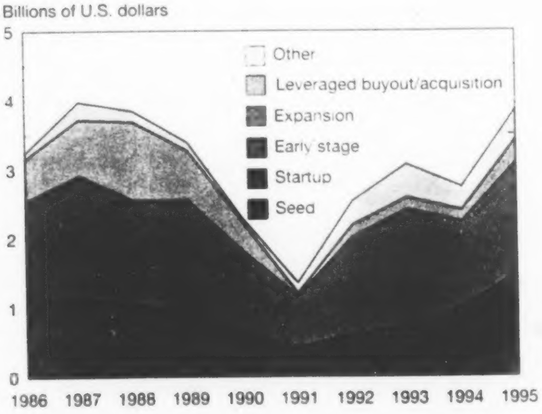
- **Management/leveraged buyout financing**—includes funds to enable operating management to acquire a product line or business from either a public or private company.
- **Turnaround financing**—provides financing to a company at a time of operational or financial difficulty, with the intention of turning the company around or improving its performance.

The first three may be referred to as early stage financing and the remaining three as later stage financing.

An examination of U.S. venture capital disbursements to companies since 1986 clearly shows that most of the funds are directed to later stage investments. Over the past 10 years, later stage investments captured between 62 and 76 percent of venture capital disbursements, with the high and low points both reached in the 1990s. (See figure 6-25 and appendix table 6-22.) Capital for company expansions attracted by far the most investor interest.

According to these data, very little venture capital goes to the struggling inventor or entrepreneur trying to prove a concept or to product development. Over the past 10 years, such seed money never accounted for more than 7 percent of all venture capital disbursements, and most often represented between 3 and 4 percent of the annual totals.[33]

Figure 6-25.
U.S. venture capital disbursements, by stage of financing



See appendix table 6-22. *Science & Engineering Indicators – 1998*

Europe's Venture Capital Industry

As in the United States, venture capitalists in Europe are attracted to young, small (under 500 employees), fast-growing companies in need of capital and management expertise. Europe now has venture-capital-backed investments all across the continent, including investments in many of the transitioning countries in Central and Eastern Europe. Data compiled by the European Venture Capital Association tracking venture capital activity in 17 countries record over 5,000 separate investments in 1996, with total disbursements exceeding $8.5 billion—an 18 percent increase over 1995.[34] (See text table 6-14.) The United Kingdom leads Europe in both the number of venture-backed investments made and the amount invested in British companies during 1996 (33 percent and 44 percent, respectively). France, Germany, and the Netherlands follow, in that order. Together with the United Kingdom, they accounted for three-fourths of all European venture capital disbursed in 1996.

While computer-related and biotechnology companies in the United States garner the lion's share of U.S. venture capital, the types of firms attracting venture capital in Europe are less technology intensive. Europe has long held a reputation for excellence in industrial machinery and equipment, fashion, and leisure products (e.g., sporting goods).These same industries are among the top recipients of European venture capital. More than 30 percent of venture capital investments (both in number and as a percentage of the total capital distributed in 1995 and 1996) were made in companies providing industrial products such as machine tools, pollution and recycling equipment, and high-fashion clothing and other consumer products. By comparison, European computer-related companies received 7 percent of the venture capital distributed in 1995 and 5 percent in 1996. European biotech companies received even less attention, although both the number and size of the investments in this industry increased in 1996 over the previous year.

European venture capitalists, like their American counterparts, direct only a small portion of capital disbursements as seed money or startup capital. Investments for expanding an existing company's productive capacity, helping a company add a new product line, or enabling a company to acquire an existing business—later stage investments—account for about 85 percent of European venture capital disbursements. For the past five years (1992 to 1996), early stage investments (as seed or startup capital) stayed below 7 percent. In fact, seed money, often used to finance research or concept development, averaged less than 1 percent from 1992 to 1995; in 1996, startup capital for product development and initial marketing reached its highest point in five years, when it represented about 6 percent of venture capital disbursements. (See figure 6-26.)

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[33] A study of new firms located in the Southwestern United States discovered that many of these firms were able to obtain substantial amounts of initial capital through strategic alliances with more established firms (Carayannis, Kassicieh, and Radosevich 1997). In that study, embryonic firms raised over $2 million, on average, in early stage capital through such strategic alliances.

[34] Data reported on venture capital investments in Europe include management buyouts, management buyins, and other later stage investments not covered in the previous discussion on venture capital investment trends in the United States.

Text table 6-14.
Number and amount of European venture capital disbursements

	1995 investments		1996 investments	
	Number	Millions of U.S. $	Number	Millions of U.S. $
European total	4,955	7,254.2	5,181	8,573.4
United Kingdom	1,716	3,443.0	1,715	3,774.0
France	994	1,113.1	1,186	1,078.0
Germany	762	871.1	769	907.9
Netherlands	280	610.8	320	752.0
Italy	220	330.9	198	647.6
Sweden	78	112.5	172	533.3
Spain	218	213.2	158	245.1
Switzerland	29	62.8	32	161.3
Belgium	132	145.2	158	138.4
Norway	163	156.0	154	105.4
Finland	114	44.5	111	50.8
Ireland	33	24.9	65	48.3
Portugal	137	71.9	74	43.2
Denmark	48	40.5	38	43.2
Greece	13	10.5	23	40.6
Austria	4	1.3	4	1.3
Iceland	14	1.3	4	1.3

SOURCE: European Venture Capital Association, *1997 Yearbook* (Zavenstem, Belgium: 1997).

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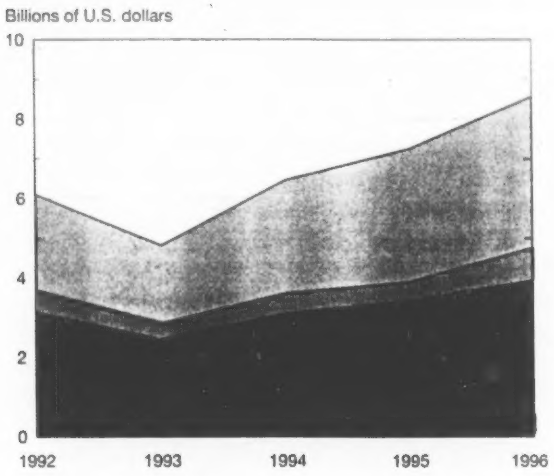
Figure 6-26.
European venture capital disbursements, by stage of financing



Disbursements in millions of U.S. dollars

		1992	1993	1994	1995	1996
Buyout	☐	2,427.45	1,967.28	2,856.04	3,364.20	3,818.14
Replacement capital	▨	523.13	405.17	516.25	463.04	829.15
Expansion	■	2,792.21	2,210.85	2,728.76	3,007.11	3,364.84
Startup	■	325.82	210.78	324.74	375.40	490.12
Seed	■	35.05	24.59	44.01	44.47	69.84
Total		6,103.66	4,818.67	6,469.80	7,254.22	8,572.09

NOTE: The financing stages used to characterize European venture capital disbursements differ somewhat from the U.S. stages used.

SOURCE: European Venture Capital Association, *1997 Yearbook* (Zavenstem, Belgium: 1997).

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New High-Tech Exporters

The previous sections identified several nations that have made tremendous technological leaps forward over the past decade. Some of these countries appear to be well-positioned to play even more important roles in technology development in the near future based on their often large and continuing investments both in science and engineering education and R&D. However, their level of participation may also hinge on other factors, among them political stability, access to capital, and the ability to complete a level of infrastructure that can support technological and economic advancement.

This section presents an assessment of future national competitiveness in high-technology industries for newly industrialized economies in Asia and in three transitioning economies—Hungary, Poland, and Russia. This competitiveness is gauged through scores on the following leading indicators:

- **National orientation**—evidence that a nation is taking directed action to achieve technological competitiveness. These actions might be explicit and/or implicit national strategies involving cooperation between the public and private sectors.
- **Socioeconomic infrastructure**—the social and economic institutions that support and maintain the physical, human, organizational, and economic resources essential to the functioning of a modern, technology-based industrial nation. Evidence of this type of infrastructure might be dynamic capital markets, upward trends in capital formation, rising levels of foreign investment, and national investments in education.

- **Technological infrastructure**—the social and economic institutions that contribute directly to a nation's capacity to develop, produce, and market new technology. Evidence of a supportive technological infrastructure might include the existence of a system for the protection of intellectual property rights, the extent to which R&D activities relate to industrial application, a nation's competency in high-tech manufacturing, and a nation's capability to produce qualified scientists and engineers from the general population.
- **Productive capacity**—the physical and human resources devoted to manufacturing products, and the efficiency with which those resources are used. A nation's productive capacity for future high-tech production can be assessed by examining its current level of high-tech production, including the quality and productivity of its labor force, the presence of skilled labor, and the existence of innovative management practices.

These four indicators were designed to identify countries that have the potential to become more important exporters of high-technology products over the next 15 years. This section analyzes 12 economies using these indicators: 9 within Asia (Singapore, South Korea, Taiwan, China, India, Indonesia, Malaysia, the Philippines, and Thailand); 2 Central European nations (Hungary and Poland); and Russia.[35]

Because Singapore, South Korea, and Taiwan have already shown impressive capabilities as exporters of high-technology products, they are often referred to as newly industrialized economies. The six remaining Asian economies are less developed technologically and are considered emerging Asian economies in this section. The three Central and Eastern European nations—Hungary, Poland, and Russia—are actively pursuing market-based reforms and are collectively referred to as transitioning economies. For this model of indicators, the Asian newly industrialized economies become the benchmark to compare expectations and technological capabilities for the other nine.[36]

National Orientation

The national orientation indicator attempts to identify those nations whose business, government, and cultural orientation encourage high-technology development. This indicator was constructed using information from a survey of international experts and published data. The survey asked the experts to rate national strategies promoting high-tech development, social influences favoring technological change, and entrepreneurial spirit. Published data were used to rate each nation's risk factor for foreign investment over the next five years (see Frost and Sullivan 1996).

The newly industrialized Asian economies posted the highest overall scores on this indicator, with Taiwan just edging out Singapore. (See figure 6-27 and appendix table 6-23.) Entrepreneurial spirit was rated much higher for Taiwan than for Singapore. This rating, derived from expert opinion, elevated Taiwan's overall score above Singapore's—despite Taiwan scoring lower than Singapore on each of the other components. While South Korea scored lower than the other two Asian "tigers" on each of the components that make up this indicator, its composite score was largely compromised by its rating as a riskier place for foreign investment than either Taiwan or Singapore.

Malaysia's national orientation toward achieving future technological competitiveness was rated far above the other emerging Asian economies and the transitioning economies in Central Europe and Russia. Across the full range of variables considered, Malaysia's scores were consistently and significantly higher than the other countries in this second group and were well within the range of scores accorded the more advanced newly industrialized Asian economies. The Philippines also scored well, with strong scores in each of the indicator components, elevating it to the second highest score among the emerging Asian economies and other transitioning economies in Central Europe.

Scores tended to converge for the remaining Asian and Central European economies, although each country's composite score is built on different strengths. Scores for Poland and Hungary were slightly higher than those for China and Thailand. Published data rated the two Central European nations a better risk for foreign investment than China, and the surveyed experts gave an edge to Poland and Hungary over Thailand on "entrepreneurial spirit."

Russia received the lowest composite score of the 12 economies examined. Two variables contributed to this standing: Russia was considered a riskier or less attractive site for foreign investment than the other countries, and the experts accorded Russia a low score on its entrepreneurial spirit.

Socioeconomic Infrastructure

This indicator assesses the underlying physical, financial, and human resources needed to support modern technology-based nations. It was built from published data on population percentages in secondary schools and in schools of higher education[37] and from survey data evaluating the mobility of capital and the extent to which foreign businesses are encouraged to invest and/or do business in that country.

Taiwan and Singapore are in a virtual tie and once again received the highest scores among the group of newly industrialized and emerging economies. In addition to strong track records on general and higher education, Taiwan and

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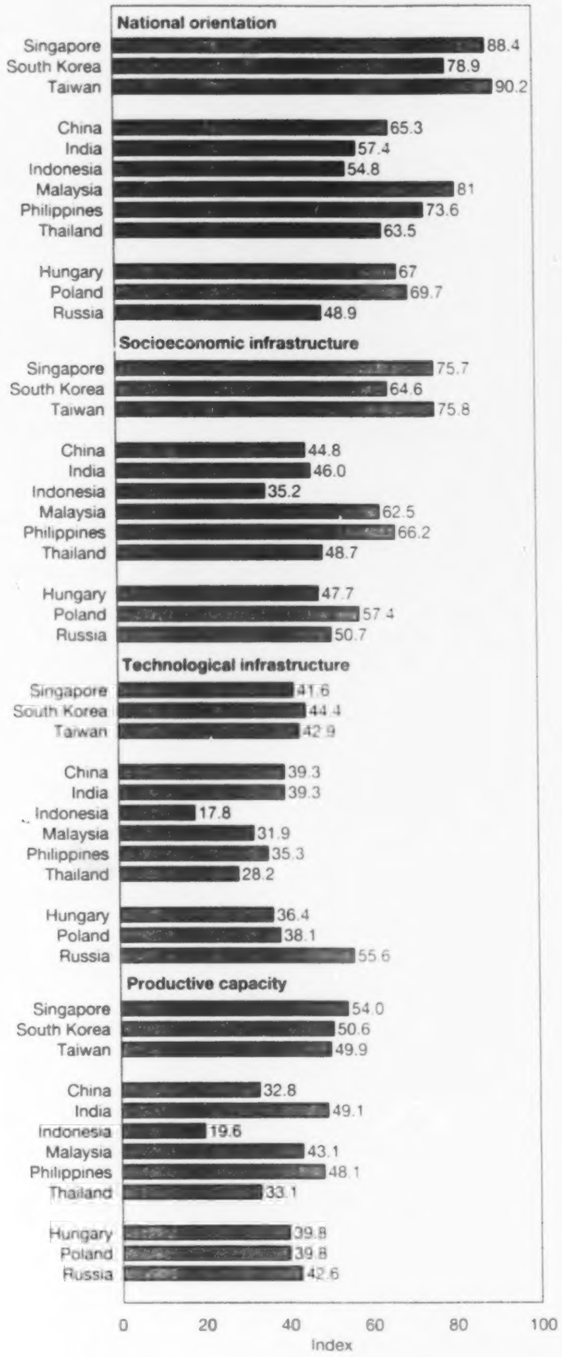
[35] See Porter and Roessner (1991) for details on survey and indicator construction; see Roessner, Porter, and Xu (1992) for information on the validity and reliability testing the indicators have undergone.

[36] Although not discussed in this section, indicator scores for Argentina, Brazil, Mexico, Venezuela, and South Africa are presented in appendix table 6-23.

[37] The Harbison-Myers Skills Index (which measures the percentage of population attaining secondary and higher educations) was used for these assessments. See World Bank (1996).

Figure 6-27.
Leading indicators of technological competitiveness: 1996



NOTE: Scores were normalized to median values of zero based on raw scores for 30 countries included in the study.

See appendix table 6-23. *Science & Engineering Indicators – 1998*

Singapore reflect high expert ratings for variables comparing the mobility of capital and for their encouragement of foreign investment. (See figure 6-27.) South Korea's overall indicator score trailed these two leaders, especially with regard to the two expert-derived variables.

Among the emerging and transitioning economies, the Philippines once again scored surprisingly well, outscoring even Malaysia. The rating for the Philippine socioeconomic infrastructure was bolstered by a stronger showing in the published education data and in the experts' higher opinion of mobility of capital in the Philippines.

Indonesia received the lowest composite score of the 12 economies examined. It was held back by low marks on two of the three variables: educational attainment—in particular, enrollments in tertiary education—and its encouragement of foreign-owned business and investment.

Technological Infrastructure

Five variables were used to develop this indicator, which evaluates the institutions and resources that contribute to a nation's capacity to develop, produce, and market new technology. This indicator was constructed using published data on the number of scientists in R&D; published data on national purchases of electronic data processing equipment; and survey data that asked experts to rate the nation's capability to train citizens locally in academic S&E, the ability to make effective use of technical knowledge, and the linkages of R&D to industry.

Russia received the highest composite score of the group of newly industrialized or transitioning economies examined here. (See figure 6-27.) Russia's score on this indicator was elevated by its large number of trained scientists and engineers, the size of its research enterprise, and its contribution to scientific knowledge—especially as compared with the smaller, less populous nations in Asia and Central Europe. Russia's composite score was more similar to mid-level Western European scores on this indicator. (See appendix table 6-23.) Poland also scored well, bolstered more by experts' rating of the quality of that country's scientists and engineers and its capacity to train new scientists and engineers, rather than on the sheer number of those professionals residing within the country.

The three Asian tigers—Singapore, South Korea, and Taiwan—compiled similar scores. Singapore scored relatively well vis-à-vis the other Asian tigers, given its small population.

The population effect shows up again in the scores of the remaining countries analyzed here. China and India both scored well, leading the other emerging and transitioning economies. Indonesia's large population, however, did not save it from the bottom ranking. It earned low scores on each of the variables making up this indicator.

Productive Capacity

This indicator evaluates the strength of a nation's current, in-place manufacturing infrastructure as a baseline for assessing its capacity for future growth in high-tech activities. It factors in expert opinion on the availability of skilled labor, numbers of indigenous high-tech companies, and management capabilities, combined with published data on current electronics production in each economy.

Singapore's productive capacity scored highest among the three Asian tigers, surpassing South Korea and Taiwan by virtue of experts' high opinion of this country's pool of labor and management personnel. (See figure 6-27.) India and the Philippines both scored quite high—in fact, their composite scores were closer to Taiwan's than to any in the group of emerging or transitioning economies. India's score was elevated by its comparatively large electronics manufacturing industry and—once again—by its tradition of training its students in science and engineering. The Philippines' score also stands out. As with Singapore, experts gave high marks to the pool of skilled labor and management talent in the Philippines. That country's scores were on a par with those received by the three Asian tigers. Although Indonesia's score for production of electronics products—this indicator's published data variable—was between that of India and the Philippines, its scores from experts rating the quality of labor and management were very low.

This model of indicators provides a systematic approach for comparing future technological capability on an even wider set of nations than might be available using other indicators. The results highlight a broadening of the group of nations that may compete in high-tech markets in the future, while also giving perspective to the large differences between several of the emerging and transitioning economies and those considered newly industrialized.

Summary: Assessment of U.S. Technological Competitiveness

This chapter brings together a collection of indicators that contrast and compare national technological competitiveness across a broad range of important technological areas. Based on the various indicators of technology development and market competitiveness examined, the United States continues to lead or be among the leaders in all technology areas. Advancements in information technologies (computers and telecommunications products) continue to influence new technology development and to dominate technical exchanges between the United States and its trading partners.

Asia's status as both a consumer and developer of high-tech products has been enhanced by the technological development taking place in the newly industrialized Asian economies—in particular, Taiwan and South Korea—and in emerging and transitioning economies such as Malaysia, China, and the Philippines. Asia's influence in the marketplace seems likely to expand in the future as other technologically emerging Asian nations join Japan as both technology producers and consumers.

Recently, several Asian nations have faced turmoil in their banking systems and capital markets. It is unclear how these developments will affect Asian economies and S&T capabilities.

The current strong position of the United States as the world's leading producer of high-tech products reflects its success both in supplying a large home-based market as well as in serving foreign markets. In addition to the nation's long commitment to investments in science and technology, this success in the international marketplace may be in part a function of scale effects derived from serving this large, demanding domestic market; it may be further aided by the U.S. market's openness to foreign competition. In the years ahead, these same market dynamics may also benefit a more unified Europe and/or a rapidly developing Asia and complement their investments in science and technology.

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Chapter 7

Science and Technology: Public Attitudes and Public Understanding

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Highlights

INTEREST IN SCIENCE AND TECHNOLOGY

- **American adults express a high level of interest in new scientific discoveries and in the use of new inventions and technologies.** This level of interest has remained high for more than two decades and reached a new high point in 1997. Individuals with more years of formal education and more courses in science and mathematics are more likely to indicate a high level of interest in science and technology.

- **About one in five Americans think that they are very well-informed about new scientific discoveries and about the use of new inventions and technologies.** Americans with more years of formal education and more courses in science and mathematics are significantly more likely to view themselves as very well-informed than others. Men are significantly more likely to indicate that they are very well-informed about science and technology, holding constant the level of formal education and the level of science and mathematics education.

UNDERSTANDING BASIC SCIENTIFIC AND TECHNICAL CONCEPTS

- **There is a wide distribution in the level of measured understanding of scientific terms and concepts among American adults.** On a 0-100 scale, the mean score was 55. This score has remained relatively constant since 1988. Individuals with more years of formal schooling and more courses in science and mathematics obtained significantly higher scores, demonstrating the pervasive effect of science and mathematics education throughout the adult years.

- **One-quarter of Americans understands the nature of scientific inquiry well enough to be able to make informed judgments about the scientific basis of results reported in the media.** Public understanding of the nature of scientific inquiry was measured through questions concerning the meaning of scientific study and the reasons for the use of control groups in experiments. Individuals who have completed more years of formal schooling and more courses in science and mathematics were significantly more likely to understand the nature of scientific inquiry than other citizens.

- **The mean score of American adults on an indicator of understanding of basic scientific concepts was tied for first with Denmark, followed closely by the Netherlands and Great Britain; it was higher than the mean scores of adults in Germany, Canada, Japan, Italy, and six other European industrial nations.** This result is in sharp contrast to results produced by American students in the Third International Mathematics and Science Study.

ATTENTIVE PUBLIC FOR SCIENCE AND TECHNOLOGY ISSUES

- **Approximately 27 million Americans—14 percent—are attentive to science and technology policy issues, a level that has increased in recent years.** In complex modern societies, it is not possible for citizens to become and remain informed about the full range of public policy areas. Some degree of issue specialization is inherent in industrial societies.

SOURCES OF SCIENTIFIC AND TECHNICAL INFORMATION

- **Americans receive most of their information about public policy issues from television news programs and newspapers.** When placed on a uniform metric of the number of uses or hours per year, the public consumption of television news and newspapers dwarfs all other information sources. In 1997, Americans watched an average of 432 hours of television news and read 196 newspapers in a 12-month period. During this same period, Americans watched 72 hours of science shows on television. Individuals with cable or satellite TV service watch more science television programs than people without this service.

- **Fifty-seven percent of Americans use a computer at home or at work.** Computer use has increased steadily during the last decade. In 1997, a typical American used a computer at work for an average of 369 hours and used a home computer for an additional 130 hours. A significantly higher proportion of college graduates use a computer than of individuals with fewer years of schooling.

- **In 1997, an estimated 11 percent of Americans lived in a household with more than one working computer.** In contrast, only 8 percent of Americans had any access to a home computer in 1983.

- **Nearly 32 million Americans have a home computer that includes a modem, and 18 percent of adults reported in 1997 that they had used an on-line computer service during the preceding year. This is a significant increase in home access to on-line resources since 1995.** In 1997, 29 percent of adults in the United States reported having a home computer with a CD-ROM reader, opening additional information acquisition opportunities. Nearly two-thirds of Americans with a graduate or professional degree have a home computer with a modem, compared to 31 percent of those with a high school degree. Similarly, 41 percent of Americans with a graduate degree reported that they use an on-line computer service, compared to only 17 percent of high school graduates.

- **Twelve percent of adults—approximately 22 million people—indicated that they had previously tried to find some specific items of information on the Web.** This pattern of response indicates that people are using the Web as they might use reference materials in a library. An analysis indicated that approximately 6.5 million Americans had attempted to find some information on the Web about a specific health condition or problem, and approximately 8.8 million had tried to find some scientific information on the Web—including information on the space program, environmental information, and computer information.

ATTITUDES TOWARD SCIENCE AND TECHNOLOGY

- **Americans continue to hold the scientific community in high regard.** According to the most recent General Social Survey, approximately 40 percent of Americans have a great deal of confidence in the leadership of the scientific community and in the leadership of the medical community. These levels of national esteem have been stable for nearly two decades and are far higher than the levels reported for the leadership of other major institutions in society.

- **Americans hold positive attitudes toward science and technology and have high expectations for future benefits from science.** When two sets of attitude questions were converted into 0-100 scales reflecting the *promise of science* and *reservations about science*, Americans posted a mean score of 70 on the Index of Scientific Promise and 37 on the Index of Scientific Reservations. This level of reservation is the lowest reported by citizens in major industrial nations. On a separate measure that asked citizens to assess the relative benefits and potential harms from scientific research, 75 percent of Americans believe tha the benefits of scientific research outweigh any present or potential harms. This level of positive assessment of scientific research has been stable for four decades and is consistent with the high esteem noted above. College graduates and citizens attentive to science and technology policy hold even more positive views of science.

- **Despite their positive views of scientific research, Americans are deeply divided over the development and impact of several important technologies:** nuclear power, genetic engineering, and space exploration. For more than a decade, Americans have been evenly divided on the benefits and harms of using nuclear power to generate electricity. A similar division exists over the benefits and potential harms of genetic engineering, but there is a clearer difference by level of education. College graduates hold a much more positive view of genetic modification research. The general public is evenly divided over the relative benefits and costs of the space program. College graduates and those who are attentive to space exploration remain very positive toward the program.

- **Nearly 80 percent of Americans agree that the Federal Government should support basic scientific research that advances the frontiers of knowledge even when it does not provide any immediate benefits.** Asked of national samples of American adults since 1985, total public approval of government support of basic scientific research has remained constant at about 80 percent throughout the last decade. During the same time period, approximately 90 percent of Americans with a baccalaureate degree voiced approval for government support of basic scientific research.

Introduction

Chapter Overview

Science and technology have become integral components of the American culture. Over 85 percent of Americans believe that the world is better off due to science, and this level of general support has continued over the last four decades. Americans believe that scientists and engineers can cure diseases, explore space, and develop ever faster modes of communication. The growth of interest in science and technology is reflected in extensive use of informal science learning resources, from television to the World Wide Web. Paradoxically, this pattern of high expectation for science and technology is not matched by a comparable level of understanding of the scientific process or of basic scientific concepts.

In a democratic society such as the United States, it is important to understand attitudes about scientific and technological issues. Over the last two decades, the *Science & Engineering Indicators* studies have built a comprehensive database that helps to illuminate patterns of change. It is equally important to apply current social science theory to the understanding and interpretation of these data. A series of analyses describes the structure and patterns of change and stability in public attitudes toward science and technology.

Today, the means of communication change as rapidly as the substance of science and technology. It is important for the scientific community to communicate with the public about the promise and needs of science. To do so requires an understanding of the sources of information that people use and of which people use each of the various kinds of media for communication.

Chapter Organization

This chapter begins with a discussion of the level of public interest in selected areas of science and technology, and examines changes in the patterns of public interest in these issues over the last two decades.[1] The level of interest in science and technology issues is an indicator of both the visibility of the work of the scientific community and of the relative importance accorded science and technology by society.

The second section of this chapter examines the level of public understanding of basic scientific concepts and the nature of scientific inquiry, looking at patterns of change over the last decade. The level of public understanding of basic scientific terms and concepts is compared for 14 leading industrial nations.

The third section of the chapter examines two sets of general, or filtering, attitudes toward science and technology. One filter reflects an individual's belief in the promise of science and technology to improve the quality of life, while another reflects the level of concern or reservation about possible negative impacts from science or technology. General attitudes in the United States and 13 other industrial nations are compared.

The fourth section analyzes the linkage between these general attitudinal filters and the policy preferences of citizens regarding government spending for basic scientific research. The development of these structural relationships over the last decade in the United States is examined, and the patterns found in the United States are compared with those for 13 other industrial nations.

The fifth section analyzes the sources of information used by citizens to improve and maintain their understanding of scientific and technical issues. This analysis examines the growth of computer access and use in the United States. New information is provided about access to electronic networks and the purposes for which individuals use the Internet.

The final section summarizes the results described in this chapter and discusses some of their major implications.

Interest in Science and Technology

Citizens of modern industrial societies like the United States live in the midst of a wide array of technologies—old and new. Most Americans now use a computer at home or work, drive automobiles controlled by computer chips, watch weather reports with satellite images only hours old, and take pharmaceuticals based on new biotechnologies unknown a decade ago. The media carry frequent reports of the results of scientific research, with a strong emphasis on biomedical research and results. The recent landing on Mars of an explorer that is essentially operated from the earth, and live coverage of the vehicle's movements and preliminary findings symbolize the interesting mix of technology and science experienced by the public.

Modern science and technology are only a part of the daily array of interesting and important news events. As interesting as science and technology may be to scientists and others knowledgeable about their activities, among the general public they compete with the demands of family and work, and many entertainment and educational opportunities. Individuals in modern industrial societies have to make choices about how they spend their time, the issues that they will attend to (if any), and the level of participation they will devote to them.

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[1] Twelve of the 13 *Indicators* volumes published since 1972 have included a chapter on public attitudes toward and understanding of science and technology. The studies for the 1972, 1974, and 1976 *Indicators* were based on a block of 20 items inserted into an omnibus national personal interview survey conducted by Opinion Research Corporation of Princeton, New Jersey. The 1979 study was designed by Miller and Prewitt (1979) and analyzed by Miller, Prewitt, and Pearson (1980); the personal interviews were conducted by the Institute for Survey Research at Temple University. Additional national studies were supported by the 1982, 1985, 1987, 1991, and 1993 *Indicators* reports, with telephone interviews conducted by the Public Opinion Laboratory at Northern Illinois University. The chapter for *Science Indicators 1985* was based on a national telephone study conducted by the Public Opinion Laboratory for Professor George Gerbner of the Annenberg School of Communication at the University of Pennsylvania. In 1995 and 1997, the Chicago Academy of Sciences conducted studies that continued the core of attitude and knowledge items from previous *Indicators* studies and included telephone interviews with a random-digit sample of 2,006 adults in 1995 and 2,000 in 1997. The interviews for the 1995 study were conducted by the Public Affairs Division of Market Facts Incorporated. The interviews for the 1997 study were conducted by the National Opinion Research Center. The results can be found in past volumes of *Indicators* (NSB biennial series). The data from these studies are available for secondary analysis from the International Center for the Advancement of Scientific Literacy at the Chicago Academy of Sciences.

Interest in Science and Technology Issues

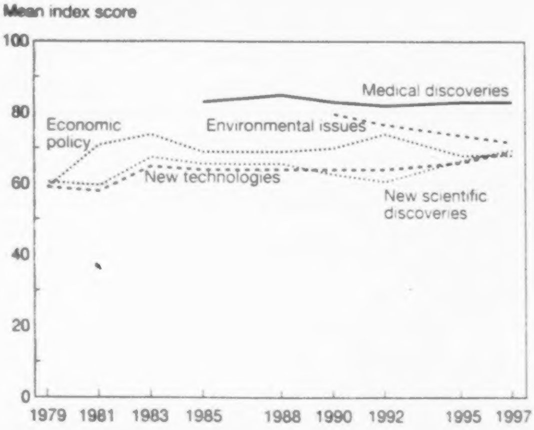
The level of interest in science and technology in the United States has remained high during the last two decades, reaching a new high point in 1997. Using a 0-100 Index of Issue Interest, the mean level of public interest in new scientific discoveries has risen from 61 in 1979 to 70 in 1997. (See figure 7-1 and appendix tables 7-1, 7-2, and 7-3.) In a parallel pattern, public interest in issues concerning the use of new inventions and technologies has grown from 59 in 1979 to 69 in 1997. Interest in medical discoveries has remained high throughout the last decade. There is some evidence that interest in environmental issues has declined slightly. In the early 1990s, interest in environmental issues was comparable to the level of interest in medical discoveries; by 1997, interest in environmental issues was about the same as interest in economic policy issues.

The level of interest in a particular issue area reflects both a core group of citizens with a long-term interest in that particular issue, plus some citizens who become more interested due to short-term policy disputes or activities. The nearly two decades of data collected by the *Science & Engineering Indicators* program demonstrate several of these patterns. The incoming Reagan Administration focused substantial attention on a reexamination of economic policies in the early 1980s, leading to a series of major disputes with Congress. These policy differences and the extensive media coverage of the debate were reflected in a substantial increase in the levels of public interest in economic issues and business conditions from 1979 to 1981, with additional growth of interest in 1993. The current Administration has emphasized the need for a strong scientific base for the United States and has focused attention on the World Wide Web and on increasing student access to computers in elementary and secondary schools.

Individuals with higher levels of formal education and more high school and college coursework in science and mathematics were significantly more likely to register higher levels of interest in new scientific discoveries, the use of new inventions and technologies, and space exploration than other citizens. (See figure 7-2 and appendix table 7-3.) In contrast, individuals with higher levels of formal education expressed only a slightly higher interest score for medical discoveries, nuclear power, and environmental issues than other adults.

In 1997, men were more likely than women to indicate a high level of interest in the use of new inventions and technologies, and space exploration. Women were more likely to express a high level of interest in medical discoveries and environmental issues than men.

Figure 7-1.
Indices of public interest in selected policy issues



NOTES: Each index is a summary measure of respondent reports that they are "very interested," "moderately interested," or "not at all interested" in each specific issue. A value of 100 was assigned to a "very interested" response, and a value of 50 was assigned to a "moderately interested" response.

See appendix table 7-1. *Science & Engineering Indicators – 1998*

Informedness About Science and Technology Issues

In contrast to the levels of interest reported above, American citizens report lower levels of information about these same issues. Nevertheless, the levels of informedness about selected scientific issues have risen over the past two decades. Using a 0-100 Index of Issue Informedness,[2] the mean level of informedness about new scientific discoveries has increased from 36 in 1979 to 49 in 1997. Informedness about new inventions and technologies experienced a similar increase—from 35 in 1979 to 44 in 1997. (See figure 7-3 and appendix tables 7-4, 7-5, and 7-6.) Throughout the last decade, the public reported the highest recorded mean level of informedness about medical discoveries.

It is important to understand how individuals assess their own knowledge of these subjects. For many purposes—from deciding which cleaning product will be most effective to writing a legislator on a current issue—it is the individual's self-assessment of his or her knowledge that will either encourage or discourage a given behavior (Rosenau 1974, Miller 1983a, and Miller 1996b). Only 16 percent of American adults think of themselves as

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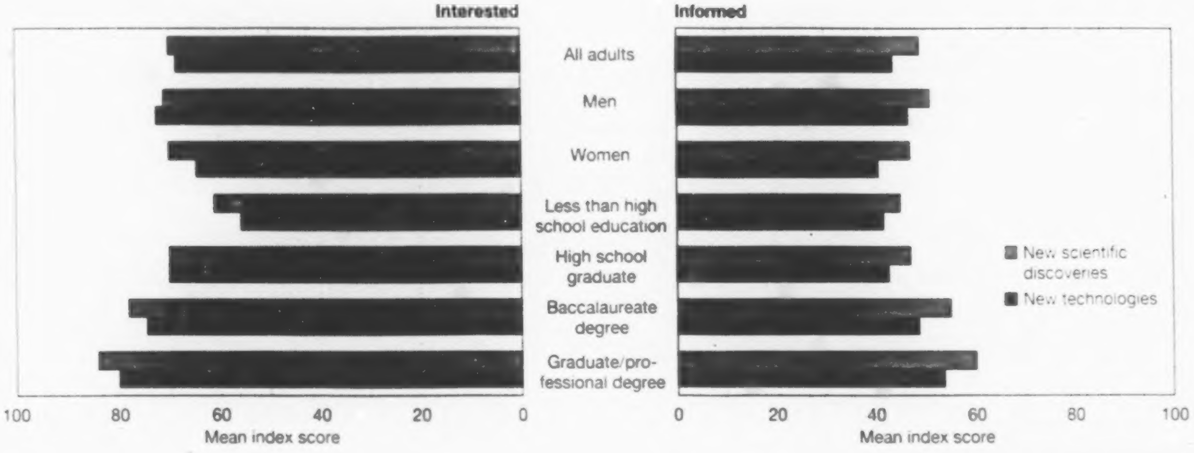
[2] "Informedness" is a useful short-hand term to denote an individual's self-assessment of his or her level of understanding of a particular issue area. The Index of Issue Informedness is a summary measure reflecting each individual's self-assessment as "very well-informed," "moderately well-informed," or "poorly informed" on a specific issue. A score of 100 points was assigned to a "very well-informed" response, and a score of 50 points was assigned to a "moderately well-informed" response. "Poorly informed" responses received a score of 0 points. The index score is the mean value of the responses for any year or group.

Figure 7-2.
Indices of public interest in and self-assessed knowledge about scientific and technological issues, by sex and level of education: 1997



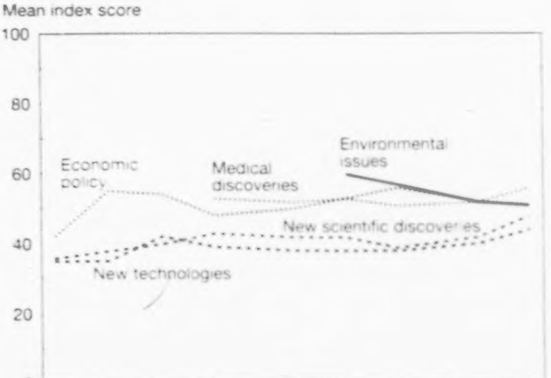
See appendix tables 7-3 and 7-6.

Science & Engineering Indicators – 1998

being very well-informed about space exploration, and only 10 percent think they are very well-informed about the use of nuclear power to generate electricity.

Comparatively, 28 percent of American adults feel that they are very well-informed about medical discoveries, and 23 percent reported that they are very well-informed about environmental issues. Medical concerns and issues tend to affect daily life for more people than issues such as nuclear power or space exploration, and it is not surprising that there is a more pervasive sense of being better informed about more personal issues than more distant ones. Similarly, individuals who can see the air pollution around major cities or who have to modify their plans due to ozone alerts or polluted beaches may feel better informed about environmental issues than about more distant topics.

Figure 7-3.
Indices of public informedness on selected policy issues



NOTES. Each index is a summary measure of respondent reports that they are "very well-informed," "moderately well-informed," or "poorly informed" about each specific issue. A value of 100 was assigned to a "very well-informed response," and a value of 50 was assigned to a "moderately well-informed" response.

See appendix table 7-4.

Science & Engineering Indicators – 1998

The influence of formal education and prior coursework in science and mathematics on most individuals' perception of their understanding about scientific and technical issues is substantial. In 1997, for example, individuals who did not graduate from high school had a mean score of 42 on informedness about the use of new inventions and technologies, compared to 54 for graduate degree-holders. (See figure 7-2 and appendix table 7-6.) In contrast, adults who did not complete high school had a mean score of 58 for informedness about medical discoveries, compared to 51 for graduate degree-holders.

Although the levels of self-reported understanding are significantly lower than the levels of interest in the same issues, the levels of self-perceived understanding are increasing. The sense of being very well-informed about new scientific discoveries increased from 13 percent in 1995 to 19 percent in 1997. Similarly, the sense of being very well-informed about the use of new inventions and technologies increased from 12 percent in 1995 to 16 percent in 1997. As discussed later in this chapter, this rise in self-perceived understanding parallels an increase in the use of science-related media and informal educational resources.

Attentiveness to Science and Technology Issues

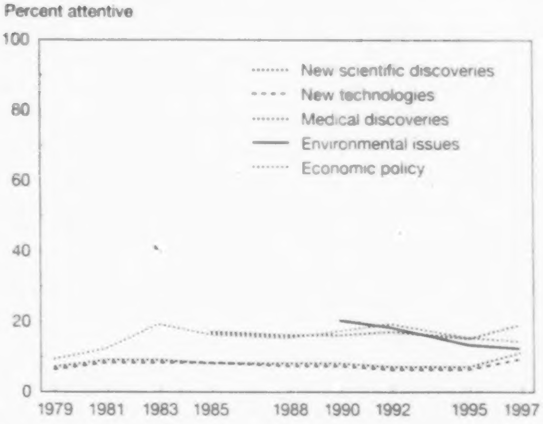
Given the large number of issues on the public policy agenda at any point in time, it is impossible for citizens to remain interested in and informed about all public policy matters. In a pluralistic society like the United States, some individuals may follow agricultural issues and foreign policy issues closely, but have little interest in science or technology issues. Other citizens may have a high level of interest in science and technology policy issues as well as foreign policy issues, but no interest in agricultural issues. All citizens, including virtually all legislators, must be selective regarding the areas and issues about which they seek to be sufficiently informed to participate in policy discussions. This process of issue specialization is a fact of political life in modern industrial societies.

Citizens who display a high level of interest in an issue area, who feel well-informed about it, and who show at least a minimal pattern of information acquisition are classified as *attentive* to that issue.[3] A citizen with a high level of interest in a particular issue, but who does not feel well-informed about it, is classified as a member of the *interested* public for that issue. Citizens without a high level of interest in a specific issue are referred to as the *residual* public for that issue area. There is an attentive public for every major public policy area; these publics differ in size and composition.

Reflecting the increased sense of informedness noted above, the percentage of American adults attentive to science and technology policy increased over the past decade, rising from 11 percent in 1988 to 14 percent in 1997. This attentive public includes approximately 27 million American adults and is the same size as the attentive public for economic policy. By comparison, 19 percent of Americans were attentive to medical discoveries in 1997, but only 12 percent were attentive to environmental issues. Only 5 percent of American adults were attentive to foreign policy and 4 percent to nuclear power issues. (See figure 7-4 and appendix table 7-7.)

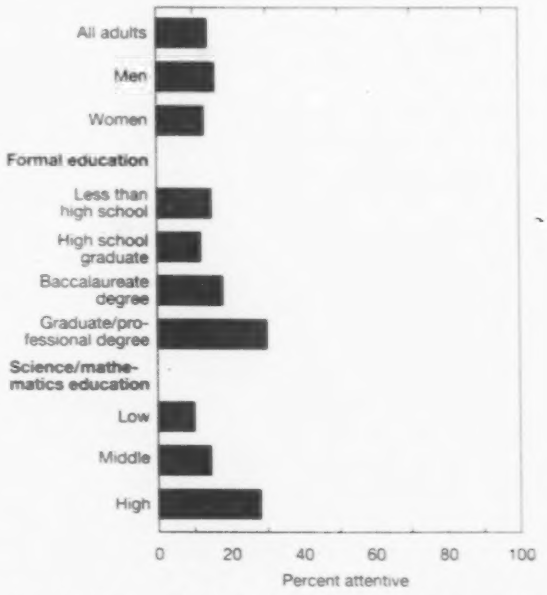
There is a direct correlation between attentiveness to science and technology policy issues and years of formal schooling and the number of science and mathematics courses taken during high school and college. (See figure 7-5 and appendix table 7-8.) Only 15 percent of individuals with less than a high school diploma are attentive to science and technology policy issues, compared to 30 percent of graduate and professional degree-holders. Similarly, 10 percent of those with limited coursework in science and mathematics were attentive to science and technology policy issues, compared to 28 percent of those with nine or more high school or college science or math courses. Men were slightly more likely to be attentive to science and technology policy issues than women, but the magnitude of this difference was smaller in 1997 than in previous years.

Figure 7-4.
Public attentiveness to selected policy issues



See appendix table 7-7. Science & Engineering Indicators – 1998

Figure 7-5.
Attentiveness to science and technology policy, by sex and level of education: 1997



See appendix table 7-8. Science & Engineering Indicators – 1998

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[3] A minimal pattern of information acquisition consists of either reading a newspaper on a daily basis or reading a weekly or monthly magazine relevant to the issue area. For a general discussion of the concept of issue attentiveness, see Almond (1950), Rosenau (1974), Miller (1983a), and Miller, Pardo, and Niwa (1997).

Understanding of Scientific and Technical Concepts

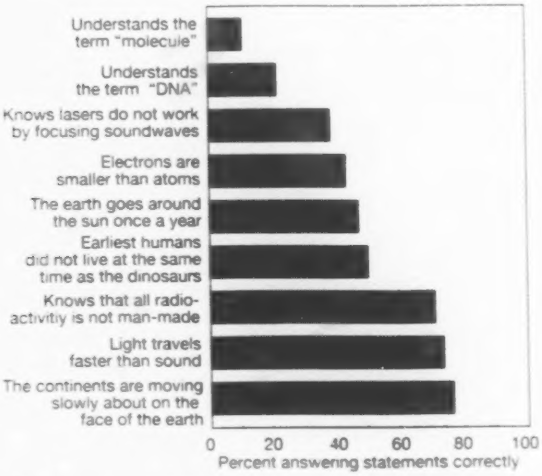
The modern citizen lives in a sea of words. The daily newspaper includes thousands of words to attract interest. Television news adds pictures and color, but requires accompanying spoken words to be enlightening. Increasingly, headlines, news stories, telecasts, magazine articles, and instruction manuals use a vocabulary of scientific terms and concepts, often assuming that most readers or viewers will understand them. This section looks at the level of public understanding of science and technology concepts.

Understanding of Basic Concepts

An understanding of a basic set of scientific concepts is an important prerequisite for understanding discussions of science and technology, and for participating in the process of formulating science and technology policy. While the range of possible scientific terms or concepts is large, it is possible to identify a sample of items that concern the composition of matter, the nature of the universe, the basic processes that have shaped our planet, and the basic biology that supports life. A set of nine knowledge items can be used to estimate the level of scientific construct understanding in the United States over the last decade.

Looking at the level of understanding on the individual items, it appears that only 11 percent of Americans can define the term "molecule." (See figure 7-6 and appendix table 7-9.) A large proportion of the population knows that a molecule is a small piece of matter, but is unable to relate it to an atom or a cell, which are also small pieces of matter. One in five Americans was able to provide a minimally acceptable definition of DNA. And, despite substantial media attention to deep space probes and pictures from the Hubble Space Telescope, only 48 percent of Americans know that the earth goes around the sun once each year.

Figure 7-6.
Public understanding of scientific terms and concepts: 1997



NOTE: See appendix table 7-9 for exact wording of statements.

See appendix table 7-9. *Science & Engineering Indicators – 1998*

On the positive side, 78 percent of Americans recognize that portions of the earth's crust—thought of in terms of continents—have been moving for millions of years and will continue to move in the future, and 75 percent know that light travels faster than sound. About 71 percent of American adults reject the idea that all radioactivity is man-made. Despite this promising level of understanding of these basic physical and geological concepts, only 39 percent of American adults disagreed with the statement that "lasers work by focusing soundwaves." Perhaps reflecting the legacy of Fred Flintstone, only half of Americans rejected the statement that "the earliest humans lived at the same time as the dinosaurs."

Using the same testing technology used in many national and international tests, the responses to these nine items were converted into a 0-100 scale.[4] The mean score for American adults on the Index of Scientific Construct Understanding was 55, the same as in 1995 and comparable to 1988 and 1990 index scores. (See figures 7-7 and 7-8 and appendix table 7-10.) Understanding of scientific constructs was strongly related to both the level of formal education and the number of high school and college science and mathematics courses taken. The mean score for college graduates was 68, compared to 44 for individuals who did not complete high school. Individuals who completed nine or more high school and college science or math courses had a mean score of 74, compared to 47 for adults who had five or fewer courses.

Men scored significantly higher than women, with a mean score of 62 compared to 49 for women. (See figure 7-7 and appendix table 7-10.) The scores partly reflect differences in coursetaking patterns, with men traditionally taking more science and mathematics courses than women. Several studies from the last decade indicate that this coursetaking gap has been nearly eliminated in mathematics and in science.[5]

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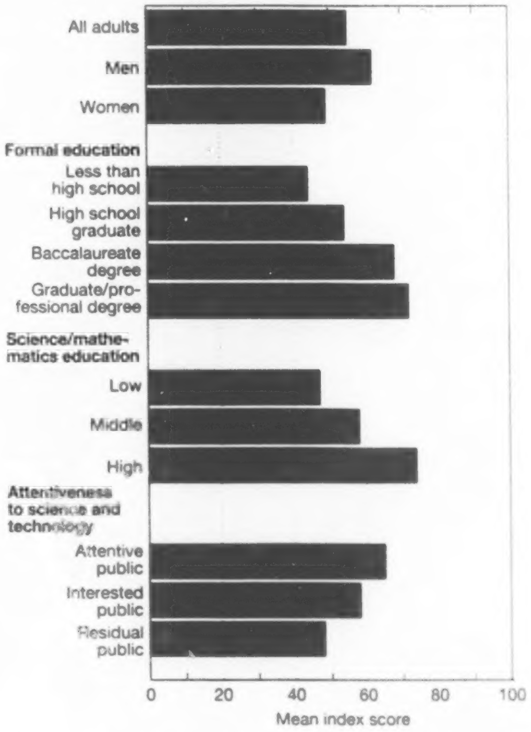
[4] The items included on the construct vocabulary dimension were first identified by a confirmatory factor analysis. To place these items on a common metric that would be applicable to studies in the United States and to studies conducted in other countries, a set of item-response theory (IRT) values were computed for each item which takes into account the relative difficulty of each item and the number of items used in each study. This technique has been used by the Educational Testing Service and other national testing organizations in tests such as the Test of English as a Foreign Language (TOEFL), the computer-based versions of the Graduate Record Examination (GRE), and the National Assessment of Educational Progress (NAEP). The original IRT score for each respondent is computed with a mean of 0 and a standard deviation of 1, which means that half of the respondents would have a negative score. To put the result in more understandable terms, the original IRT score was converted to a 0-100 scale. See Zimowski et al. (1996) for a more complete discussion of item response theory. For more information on confirmatory factor analysis, see Long (1983) or Loehlin (1987).

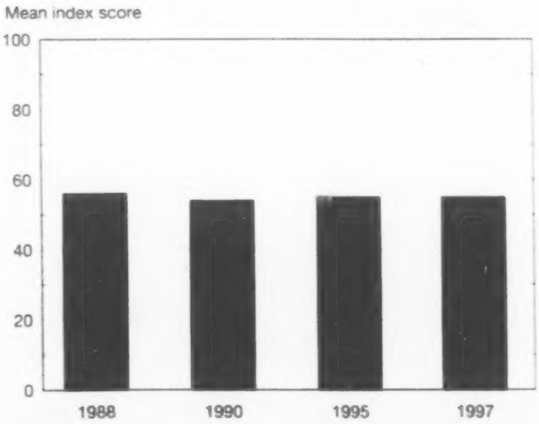
[5] See Legum et al. (1993), Matti et al. (1994), and NCES (1997) for a more complete discussion of changes in mathematics and science coursetaking by sex.

Figure 7-7.
Mean score on Index of Scientific Construct Understanding, by sex, level of education, and attentiveness to science and technology: 1997



See appendix table 7-10. *Science & Engineering Indicators – 1998*

Figure 7-8.
Mean score on Index of Scientific Construct Understanding



SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

Science & Engineering Indicators – 1998

Understanding of Scientific Inquiry

To handle the daily flow of news reports about scientific and medical findings, citizens must understand the nature of scientific inquiry. A major difficulty in measuring the public understanding of scientific inquiry is that science does not utilize a single uniform procedure. While some sciences rely heavily on experimental procedures, others depend primarily on observation, measurement, and model building and testing. Other sciences depend heavily on fossil discovery, classification, and the construction or integration of possible developmental sequences. Virtually all of these approaches are utilized to some degree under the broad umbrella of scientific inquiry.

What is central to all scientific endeavor, however, is the effort to build theories or models to enhance our understanding of nature and the materials and processes found in nature. Parallel to the theory-building process is a commitment that all theories must be subject to logical or empirical falsification. Thus, the first level of conceptualization of science is an activity for the purpose of building and testing theory.[6]

At a second level, some individuals think of all scientific inquiry as a form of experimental investigation. This may reflect an understanding that scientific ideas are subject to testing. Popper's concept of falsification is not widely known (Popper 1959), and most people still think that scientists prove their theories or ideas much as a mathematician might "prove" a theorem. Thus, a second important level of public understanding of scientific inquiry involves the view of science as the conduct of experimentation. This view is reinforced by frequent media reports of medical and pharmaceutical trials of new procedures or products.

At a third level, some people simply think of science as rigorous comparison. This view of science is largely devoid of any notion of theory building. It lacks understanding of experimentation as the use of random assignment and control groups, or of the purposes for those procedures. It does view science as empirical in character, often perceiving science as "testing," as against some known standard.

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[6] While there is broad consensus that theory building is the primary objective of science, this level of conceptualization is relatively rare in the public and not universal among graduates of science, engineering, or medical programs. The measurement of the understanding of scientific inquiry at this level is compounded by the dual meaning of "theory" in American English. In the usage employed above, "theory" refers to comprehensive sets of statements about the operation of various aspects of nature, or the development of models of natural processes. This usage would apply to generalizations or models in the biological, social, or physical sciences. At the same time, "theory" is often used in everyday language to refer to speculations or suppositions not yet supported by evidence. For example, it is common to hear a person dismiss a speculation by another person by saying that it is "only a theory," meaning that there is no evidence, or insufficient evidence, for that conclusion. Ironically, this is almost exactly the opposite meaning of the term as used in science.

This duality of meaning creates an interesting measurement problem. When a respondent is asked, for example, what it means to study something scientifically, and responds that it has to do with "making theories and things," it is not clear whether the individual means to use theory in a Kuhnian (Kuhn 1962) sense or as an unsupported speculation. For this reason, it is important to ask these questions in an open-ended format and to probe the responses.

Below these levels of conceptualization, many individuals have some awareness of the word "science," but no cognitive substance behind the word. It may be associated with precise measurement or with good or bad outcomes (medical miracles or weapons of mass destruction), but the work of scientists and the process of scientific inquiry are not understood. Most of these individuals hold positive attitudes toward science, and expect it to cure most diseases and to solve environmental problems. There is, however, a higher level of reservation among these individuals, which may reflect their recognition of the enormous power of science and technology and their inability to understand it.

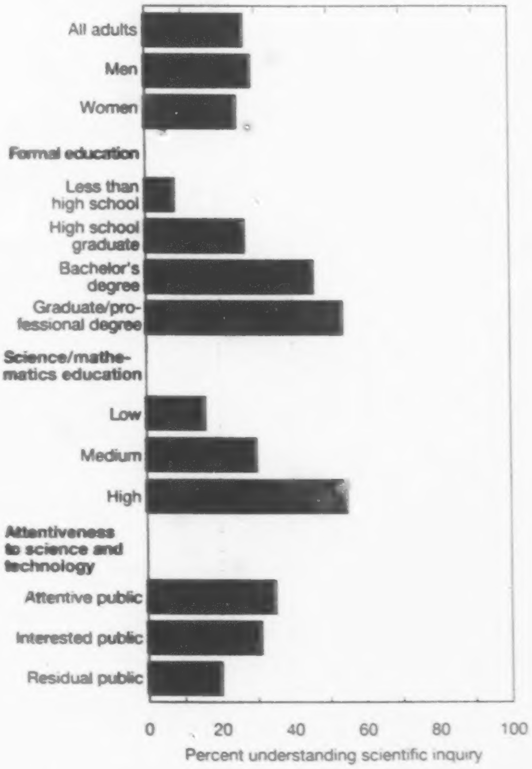
To find out how well the public understands the nature of scientific inquiry, adults have been surveyed in a series of *Science & Engineering Indicators* studies over the last decade. They were asked to define the meaning of scientific study, and their responses have been recorded and coded. In 1995 and 1997, each respondent was asked the same open-ended question about scientific study and given a set of questions concerning an experimental evaluation of a drug.[7] They were also asked a set of questions concerning the meaning of probability, using an example of an inherited illness.[8] Each respondent was classified, using a combination of these responses, as having or not having at least a minimal level of understanding of the nature of scientific inquiry.[9] In 1997, approximately 27 percent of American adults met the standard of having a minimal understanding of the nature of scientific inquiry, continuing a gradual increase over the last decade. (See figure 7-9 and appendix table 7-11.)

International Comparisons

It is possible to obtain a sense of international commonalties and differences by comparing the mean scores on the Index of Scientific Construct Understanding for 14 of the leading industrial nations. Using the 100-point index described above, the United States, Denmark, the Netherlands, and Great Britain all produced mean scores of between 53 and 55. (See figure 7-10 and appendix table 7-12.) Although the years in which the data were collected from the other countries range from 1989 to 1992, the provision of the three time periods for the United States illustrates the stability of the U.S. estimate; there is no basis for assuming a more rapid change in other major industrial nations.

The results of the Third International Mathematics and Science Study (TIMSS) are relevant to this discussion since they showed that students in the United States ranked in the middle range of industrial countries. (See chapter 1.) There are a number of plausible reasons why American adults may

Figure 7-9.
Public understanding of the nature of scientific inquiry: 1997



See appendix table 7-11. *Science & Engineering Indicators – 1998*

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[7] The question on the meaning of scientific study was:

"When you read news stories, you see certain sets of words and terms. We are interested in how many people recognize certain kinds of terms, and I would like to ask you a few brief questions in that regard. First, some articles refer to the results of a scientific study. When you read or hear the term scientific study, do you have a clear understanding of what it means, a general sense of what it means, or little understanding of what it means?"

If response is "clear understanding" or "general sense": "In your own words, could you tell me what it means to study something scientifically?"

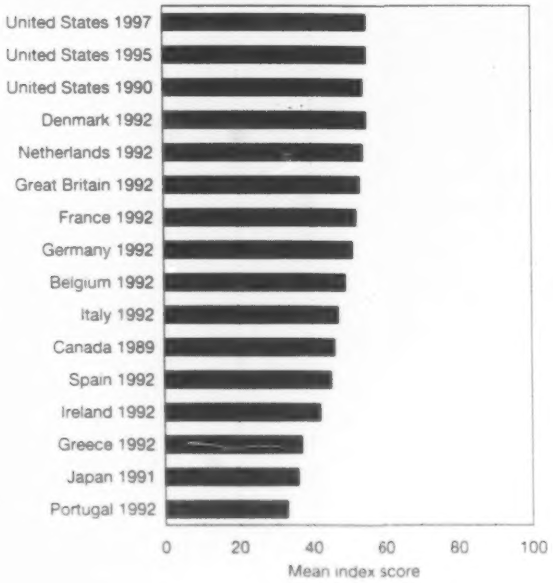
In addition, each respondent was asked the following question:

"Now, please think of this situation. Two scientists want to know if a certain drug is effective against high blood pressure. The first scientist wants to give the drug to 1,000 people with high blood pressure and see how many experience lower blood pressure levels. The second scientist wants to give the drug to 500 people with high blood pressure, and not give the drug to another 500 people with high blood pressure, and see how many in both groups experience lower blood pressure levels. Which is the better way to test this drug? Why is it better to test the drug this way?"

[8] The text of the probability question was: "Now think about this situation. A doctor tells a couple that their 'genetic makeup' means that they've got one in four chances of having a child with an inherited illness. Does this mean that if their first three children are healthy, the fourth will have the illness? Does this mean that if their first child has the illness, the next three will not? Does this mean that each of the couple's children will have the same risk of suffering from the illness? Does this mean that if they have only three children, none will have the illness?"

[9] The level of understanding of the nature of scientific inquiry is estimated by looking at responses to a series of open-ended and multiple-part questions. To qualify as understanding the nature of scientific inquiry, a respondent had to (1) either provide a theory-oriented response to an open-ended question about the meaning of scientific study or provide a correct response to an open-ended question about an experiment and (2) be able to provide a correct response to a series of four separate queries about the meaning of the probability of one-in-four, using an example of an inherited illness.

Figure 7-10.
Mean score on Index of Scientific Construct Understanding in 14 countries



See appendix table 7-12. *Science & Engineering Indicators – 1998*

score ahead of, or equal to, adults in other industrial nations. First, a higher percentage of U.S. youth have enrolled in postsecondary schooling for most of the last five decades. A second possible reason is that there has been and continues to be a more pervasive use of general education requirements in the United States, which include one or more years of college-level science instruction for all college students, regardless of degree or career objective. In Europe and Japan, fewer youth enroll in college or university, and postsecondary students who do not plan a career in science or related fields are not required to take college-level science or mathematics courses. It is also possible that college-level science instruction in the United States is enhanced by informal science learning resources. These include zoos, aquariums, museums, science television programs, science magazines, public libraries, and the World Wide Web. Other reasons are based in the methodologies of these studies. The ability of TIMSS performance to predict a student's adult knowledge has not been established. Different testing instruments and procedures can lead to substantial differences in results. The factors associated with these differences merit further study.

Attitudes Toward Science and Technology Policy Issues

One of the areas of inquiry that social psychology and learning research has focused on is the development of public attitudes toward a variety of subjects. How humans learn, think, and develop cognitive structures is an evolving and complex area of research. Some of the social psychology concepts are helpful in the analysis of public attitudes toward science and technology. Some social psychology literature indicates that most individuals, when faced with a daily barrage of complex information, often construct schemas to filter and manage information (Schank 1977; Minsky 1986; Lau and Sears 1986; Milburn 1991; and Pick, van den Broek, and Knill 1992).

A schema is a psychological structure that humans use to integrate information and experiences into coherent clusters. Individuals have schemas for simple tasks (such as driving an automobile in traffic) as well as for more complex and abstract tasks (such as understanding the impact of science on society). Schemas are usually cumulative in character and help people categorize new information while also providing an initial filtering response to the information. For example, when a driver sees a lighted arrow pointing to one side of a highway, it is likely that the driver will assume the need to turn in that direction, and may also reason that it will be necessary to slow the vehicle first. The original observation of the lighted arrow activates various prior experiences and knowledge, bringing into short-term memory a set of alternative explanations and associated behaviors.

Similarly, when an individual hears or reads a news report that a new drug tested on a large number of animals was found to reduce the development of cancer, that information may be recognized as a "scientific study" and one or more schema relevant to this subject may be activated. Although the report involves tests of a drug on animals, the individual may recognize that the results could lead to studies with more advanced animals or with humans, ultimately resulting in a drug that might be useful to humans. An individual with a strong positive schema toward science may interpret this report optimistically, expecting new medications in the foreseeable future, and reinforcing a belief that science produces things that make life healthier, easier, and more comfortable. Conversely, an individual with a strong negative schema toward science may recall other test reports that have promised results, but failed to produce them.

It is important to explore the structure of public attitudes toward science and technology in the United States and to compare it with structures found in other industrial nations. To do that, a series of analyses was conducted, and two independent dimensions were found that support the view that most individuals hold two primary schemas toward science and technology. The first dimension appears to represent belief in the promise of science and technology. A careful reading of the four items included on this dimension indicates that they all reflect either the judgment that science and technology have already improved the quality of life, with the implicit assumption that this will continue, or make a positive assessment of the likelihood of future benefits. The second dimension appears to represent personal reservations about science and technology. The four items included on this dimension express concerns about the speed of change in modern life and a sense that science may, at times, pose conflicts with traditional values or belief systems.

It is reasonable to expect many combinations of these two schemas. Some individuals may have a strong belief in the promise of science and technology and a low level of concern, leading them to react positively to a wide spectrum of science news. Alternatively, some individuals may have lower expectations about the promise of science and technology and a higher level of concern, leading them to be doubtful or negative about scientific news. It is also possible for an individual to hold both hope in the promise of science and technology and real reservations about their potential harms or dangers. Given the low salience of science and technology to many adults, it is likely that some people will have both low expectations about the promise of science and technology and little awareness or concern about potential drawbacks.

To provide a common metric for comparison, a 0-100 index was constructed for the Index of Scientific Promise and the Index of Scientific Reservations. The mean score of U.S. adults on the Index of Scientific Promise was 70 in 1997, and the mean score on the Index of Scientific Reservations was 37.[10] (See appendix tables 7-13 and 7-14.) Although the ratio between the two indices may show the relative strength of positive and negative attitudes toward science and technology, both schema operate simultaneously in most individuals. This pattern means that most Americans hold strong beliefs in the promise of science and technology to improve the quality of life and have relatively low levels of reservation about possible harms. Comparable indicators from 1992 and 1995 suggest that this pattern of American attitudes has remained stable in recent years.[11]

A comparison of the United States and 13 other industrial nations shows that the citizens of most industrial countries hold strong positive beliefs about the promise of science and technology to improve the quality of life. (See appendix table 7-16.) The citizens of the other 13 industrial nations had a mean score around 70 on the Index of Scientific Promise, suggesting a pervasive belief in the potential benefits of science and technology to improve the quality of life.

There are, however, major differences among industrial nations in the level of reservation, or concern, about potential negative effects of science and technology on traditional values and on the pace of life. Among industrial nations, American adults report the lowest levels of reservation about science and technology, with a mean score of 37. Canadians and most Europeans recorded mean reservation scores between 50 and 60, but the citizens of Greece and Portugal displayed mean scores above 66. This pattern suggests that these citizens simultaneously believe in the promise of science and technology to improve the quality of life, and hold a slightly lower—but substantial—level of concern about potential negative impacts of science and technology.

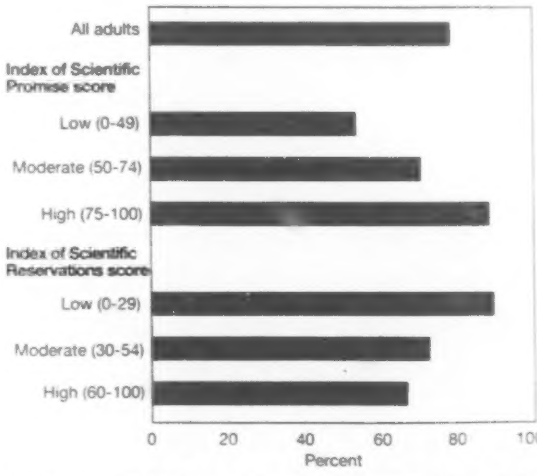
Japan is an interesting exception to this pattern. The mean score for Japanese adults on the promise index was 55, but the mean score on the reservation index was 56. The level of reservation is comparable to Canada and most European countries, but the level of belief in the promise of science and technology to improve the quality of life is essentially equal to the level of concern. While this pattern is surprising in the context of Japanese success in science and technology in recent decades, it may be a reflection of a traditional society experiencing a faster pace of social and economic change than earlier generations.

The Linkage Between Schema and Specific Policy Preferences

To learn how these general schema function with regard to specific policy preferences, it is useful to view the responses of Americans to the statement, "Even if it brings no immediate benefits, scientific research which advances the frontiers of knowledge is necessary and should be supported by the Federal Government." Nearly 80 percent of Americans agreed with that statement in 1997, and only 18 percent explicitly disagreed with it. (See figure 7-11 and appendix table 7-17.) The same question has been asked of Americans in each of the *Science & Engineering Indicators* studies since 1985, and the results suggest that this level of support has been stable for at least a decade. Approximately 90 percent of American adults with a baccalaureate degree have voiced approval for this statement since 1985.

A careful examination of the data from 1997 suggests that these two schema play an important intermediary role in the development of specific policy preferences, such as the preference for government funding for basic scientific

Figure 7-11.
Support for government funding of basic scientific research, by level of general support for or reservations about science and technology: 1997



See appendix table 7-18. *Science & Engineering Indicators – 1998*

research. About 54 percent of American adults who scored less than 50 on the Index of Scientific Promise agree that the Federal Government should fund basic scientific research. By contrast, 89 percent of adults with a score of 75 or more on the index supported that funding. (See figure 7-11 and appendix table 7-18.) Similarly, the level of support ranges from 67 percent among adults with a high level of reservation about the impact of science and technology to 90 percent among adults with a low level of reservation. By itself, this pattern would suggest that both of these schema operate simultaneously and in opposite directions, but other factors—such as level of education and the number of science courses taken—influence the general schema themselves; thus, the relationship is more complex. The influence of education, for example, can be seen in the percentage of support by schema score among those with different levels of education. (See appendix table 7-18.) These results confirm that both the promise schema and the reservation schema continue to operate within every level of formal education.

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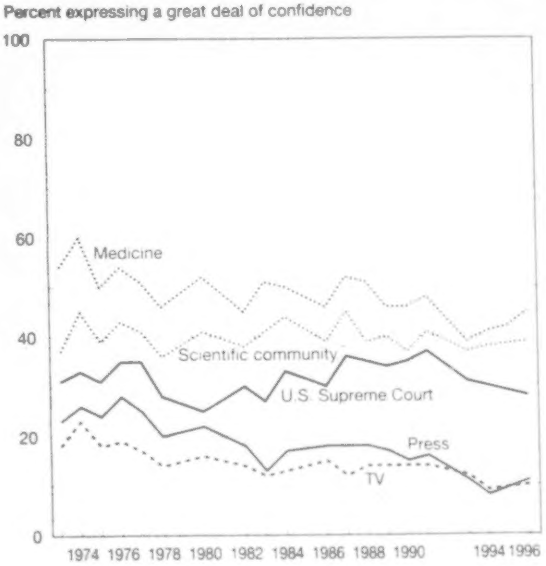
[10] See appendix table 7-14 for the frequency distribution of the eight items included in the two schema.

[11] Some of the items included in the Index of Scientific Reservations and the Index of Scientific Promise were included in the Attitude Toward Organized Science Scale that was reported in previous *Science & Engineering Indicators*. (See appendix table 7-15.)

The results show that schema—general and long-term attitudinal filters—play an important role in the formulation and maintenance of more specific policy attitudes and preferences. It is useful to examine some additional indicators of public attitudes toward organized science in the United States.

One of the oldest indicators of the public attitude toward science and technology is the General Social Survey query (Davis and Smith annual series), which asks Americans whether they have a "great deal of confidence, only some confidence, or hardly any confidence at all" in the people running selected institutions. About 40 percent of Americans express a great deal of confidence in the leadership of the scientific community, trailing only the leadership of medicine. (See figure 7-12 and appendix table 7-19.) Comparatively, only 10 percent of adults expressed a great deal of confidence in the leadership of the press or television in 1996. This level of esteem for the leadership of the scientific community has continued during the two decades that these data have been collected.

Figure 7-12.
Public confidence in leadership of selected institutions



See appendix table 7-19. *Science & Engineering Indicators – 1998*

Perceptions of Scientific Research

The longest available indicator of the relative benefits and harms of science is a question that Americans were first asked only weeks before the launch of Sputnik I in 1957. Asked to judge whether the world is better or worse off because of science, 88 percent of American adults said they thought the world was better off, and only 3 percent said that the world was worse off (Davis 1958). In the 1988 *Science & Engineering Indicators* study, this question was repeated and 88 percent still said that the world was better off due to science. In 1997, 40 years after Sputnik, 87 percent indicated that they felt that the world is better off because of science, and only 5 percent said that the world is worse off due to science. This pattern reflects a consistent post-war belief among Americans that science will improve the quality of life.

When asked in 1997 to weigh the benefits and harms of "scientific research," 75 percent of Americans indicated that the benefits had exceeded any harms, and only 12 percent took an opposing view. (See figure 7-13 and appendix table 7-20.) In 1997, 90 percent of Americans with a college degree indicated that the benefits of scientific research outweigh any harms, compared to 58 percent who did not finish high school. Of the attentive public for science and technology policy (those most likely to become involved in science or technology policy disputes), 83 percent believed that the benefits of scientific research outweigh any harms.

Perceptions of Nuclear Power

Americans are not as positive about all scientific issues as they are about scientific research generally. For example, they have been evenly divided for more than a decade over the use of nuclear power to generate electricity. In 1997, 45 percent of Americans believed the benefits of nuclear power outweighed any harms, while 37 percent held the opposite view, and 18 percent thought that benefits and harms were equal. (See figure 7-14 and appendix table 7-21.)

Individuals with more years of formal schooling, males, and citizens attentive to science and technology policy were slightly more favorable in their assessment of the benefits and harms of nuclear power than other Americans, but the differences were modest.[12] (See appendix table 7-21.) The relationship between education and the assessment of nuclear power was relatively weak.

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[12] These differences in attitudes by sex toward nuclear power are consistent with the findings of other studies conducted in the United States and Europe (Shapiro and Mahajan 1986, Norris 1988, and Poole and Zeigler 1985).

These data show that a majority of the attentive publics for science and technology policy and for biomedical research (medical discoveries) has held a positive assessment of the benefits and harms of genetic engineering since 1985. (See appendix table 7-22.) For both attentive publics, the proportion of citizens who see the benefits and harms as about equal, or who cannot determine the difference, has been growing since 1985.

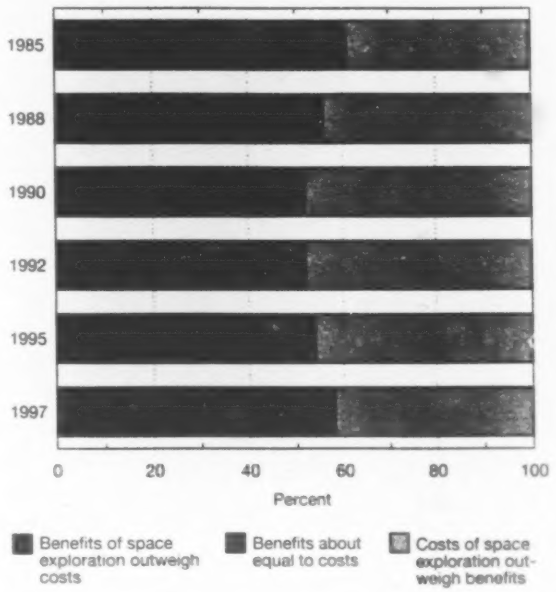
There is a clear difference by sex on this issue. In 1997, nearly 50 percent of men expressed a positive view of genetic engineering, compared to 37 percent of women. (See appendix table 7-22.) Approximately half of American men favored genetic engineering throughout the last decade. American women were nearly equally divided in 1997, with 37 percent indicating that the benefits outweigh the harms and 40 percent saying that the harms outweigh the benefits.[13]

Perceptions of Space Exploration

The balance between benefits and costs, rather than benefits and harms, has been important in assessment of the space program. While a majority supported the program in 1985, a small plurality of the public thought that the costs exceeded the benefits of space exploration in the early 1990s; public perceptions shifted toward the view that the benefits of space exploration exceeded its costs in 1997. (See figure 7-16 and appendix table 7-23.) This pattern of change offers an interesting insight into the role of attentive publics for low-salience issues.

In 1985, immediately prior to the Challenger accident, 54 percent of Americans thought that the benefits of the space program outweighed its costs. However, 66 percent of the attentive public for science and technology policy, and 74 percent of the attentive public for space exploration, believed that the benefits outweighed the costs and tended to hold strong feelings on this matter. The explosion of the Challenger produced an immediate increase in support for the space program in all segments of the American public (Miller 1987), but the grounding of the shuttle program for more than two years eroded a great deal of that support. Through the late 1980s and early 1990s, support was declining in both the general public and among those attentive to science policy. By 1992, however, fully 82 percent of the attentive public for space exploration believed that the benefits of the space program were greater than its costs. Although the interviews for the present *Indicators* study were largely completed prior to the Mars landing, a series of successful shuttle flights and a steady flow of images from the Hubble Space Telescope produced a small surge in public support.

Figure 7-16.
Public assessment of space exploration



See appendix table 7-23. *Science & Engineering Indicators – 1998*

By the summer of 1997, 48 percent of American adults felt that the benefits of the space program exceeded its costs, while 42 percent of adults continued to think that the costs were greater than the benefits. (See appendix table 7-23.) At the same time, 66 percent of the attentive public for science and technology policy, and 76 percent of the attentive public for space exploration, indicated that the benefits exceeded the costs.

Sources of Scientific and Technical Information

In recent decades, there has been a marked increase in the number and variety of sources providing information about science and technology.[14] Major weekly news magazines generally have a section on science or medicine and a section on computers and networks. The number of popular science books continues to grow, and many reviewers conclude that the quality of them is increasing. There has been substantial growth in cable television coverage of science and technology, and the number and quality of science-related sites on the World Wide Web grows daily. In this context, it is interesting to find out which Americans are using which kinds of science and technology information sources, and to what effect.

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[13] Hoban and Kendall (1993), in a study conducted in the United States, also found that men hold more positive views of biotechnology. A 1993 European study of attitudes toward biotechnology also found that men hold more positive attitudes toward biotechnology and genetic engineering (see Marlier 1993).

[14] See Lewenstein (1994) for a survey of public communications about science and technology in the United States.

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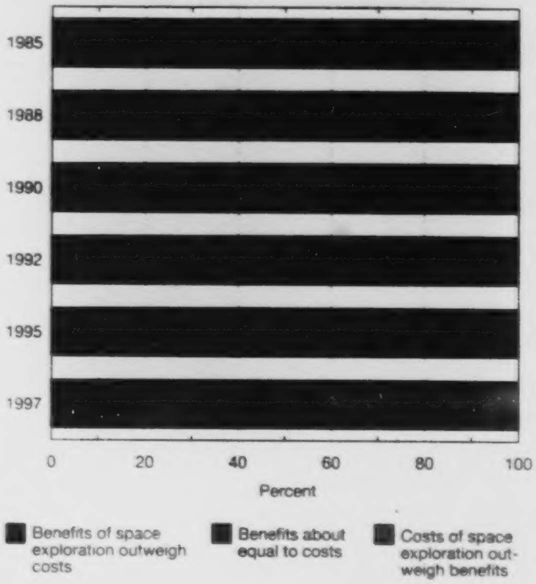
Figure 7-16.
Public assessment of space exploration



See appendix table 7-23. *Science & Engineering Indicators – 1998*

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Sources of Scientific and Technical Information

In recent decades, there has been a marked increase in the number and variety of sources providing information about science and technology.[14] Major weekly news magazines generally have a section on science or medicine and a section on computers and networks. The number of popular science books continues to grow, and many reviewers conclude that the quality of them is increasing. There has been substantial growth in cable television coverage of science and technology, and the number and quality of science-related sites on the World Wide Web grows daily. In this context, it is interesting to find out which Americans are using which kinds of science and technology information sources, and to what effect.

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[14] See Lewenstein (1994) for a survey of public communications about science and technology in the United States.

General Patterns of Information Acquisition

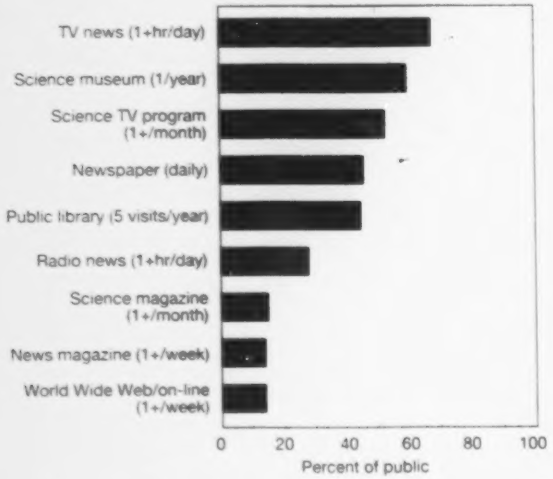
Building on trend data from previous *Science & Engineering Indicators* studies, it appears that Americans utilize numerous sources and institutions for scientific and technical information, but television and newspapers remain primary sources. In 1997, 68 percent of American adults reported that they watched a television news show for at least one hour on a typical day, and 46 percent indicated that they read a daily newspaper. (See figure 7-17 and appendix table 7-24.) Over one-quarter of Americans listen to one or more hours of radio news on a typical day, and 14 percent claim to read a weekly news magazine on a regular basis. Fifteen percent reported that they read a science magazine on a regular basis. These same results show that 70 percent of Americans use a public library at least once each year and that 45 percent claim to use a pubic library five or more times each year, although it is not possible to determine from the data whether science materials were utilized. Approximately 27 percent[15] of American adults now have access to the World Wide Web, and approximately 28 percent[16] report having an e-mail address at home or at work.

In broad terms, these indicators are threshold measures, reflecting the percentage of Americans who used various information sources more than some minimal threshold in a typical month or during the previous year. Using the same database, it is also possible to estimate the volume of use of these information sources and to place them all on the same metric—the number of uses or hours of use per year. By comparing different information sources on the same metric, it is possible to obtain a more useful picture of the patterns of potential scientific and technical information acquisition.

Regarding broadcast media, the 1997 results indicate that Americans watch an average of 1,075 hours of television each year and that 432 of those hours are devoted to television news. (See figure 7-18 and appendix table 7-25.) In this context, Americans report that they watch an average of 72 hours of science television per year. Since respondents in 1997 were asked the name of each show that they claimed to watch regularly or periodically, this is a credible estimate of viewership. The frequency of viewing science television shows is unrelated to the number of years of formal schooling or to the number of science and mathematics courses taken in high school and college. It is apparent, however, that individuals who subscribe to a cable television service or have a satellite dish watch significantly more science television shows than individuals without cable or satellite services. In 1997, cable subscribers reported watching an average of 84 hours of science television shows, compared to 35 hours for individuals without cable or satellite service. Men were significantly more likely to watch science television shows than were women.

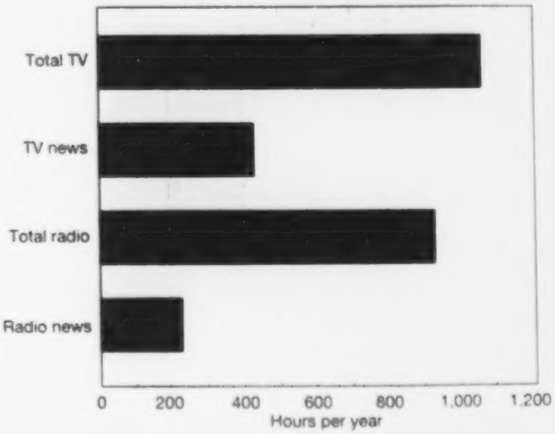
Among print media, newspaper reading is dominant. In 1997, Americans reported reading an average of 196 newspapers during the previous 12 months. (See figure 7-19 and appendix table 7-25.) Comparatively, Americans read an average of three news magazines and two science magazines during the same 12-month period. Americans in 1997 used a public library 11 times during the year and borrowed 12 books and 2 videotapes from the public library. Sixty-one percent of American adults reported that they bought one or more books during the previous year; and 31 percent indicated that at least one of the purchased books involved science, mathematics, or technology (including computer use).

Figure 7-17.
Public use of selected information sources: 1997



See appendix table 7-24. *Science & Engineering Indicators – 1998*

Figure 7-18.
Mean number of hours per year of television and radio use: 1997



See appendix table 7-25. *Science & Engineering Indicators – 1998*

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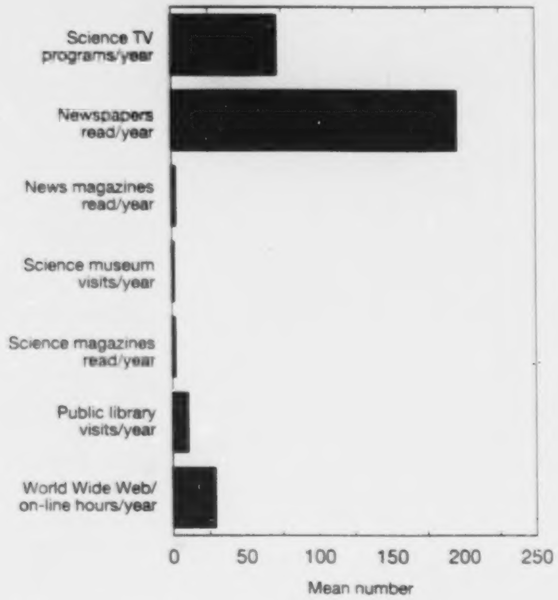
[15] This estimate includes individuals with access to the World Wide Web through their home computer, their work computer, and through Web television (not reported in the appendix tables).

[16] This estimate combines those individuals who have an e-mail address either at home or at work, and is not reported as a separate category in the appendix tables.

Figure 7-19.
Public use of selected information sources, on an annual basis: 1997



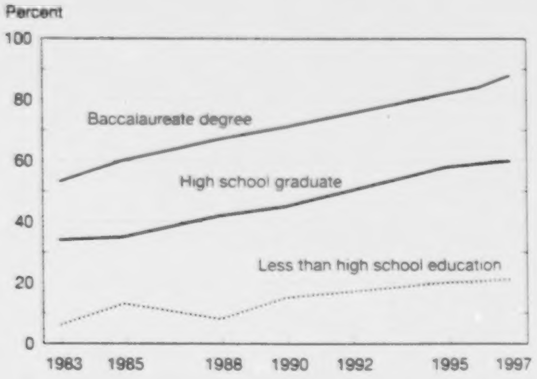
See appendix table 7-25. *Science & Engineering Indicators – 1998*

During the same 12-month period, Americans reported visiting a science museum, natural history museum, zoo, or aquarium an average of two times.

The reading of newspapers, news magazines, and science magazines is positively related to the number of years of formal schooling and the number of high school and college science and mathematics courses. (See appendix tables 7-24 and 7-25.) The individual with a graduate degree read approximately 238 newspapers, 6 news magazines, and 4 science magazines in a 12-month period. It appears that high school and college science and mathematics courses stimulate a lasting interest in science and technology, as reflected in the patterns of science magazine reading and science museum attendance. Men were significantly more likely to read a science magazine than were women.

Citizens attentive to science and technology policy issues displayed a high level of information consumption, utilizing both broadcast and print sources. Science policy attentives reported slightly more hours of television news viewing than other citizens, and they read significantly more newspapers than other Americans. (See appendix table 7-25.) Science and technology policy attentives read significantly more news magazines and science magazines than other citizens, and were more frequent visitors to public libraries than nonattentives. The members of the attentive public for science and technology policy were more likely than other Americans to visit a science and technology museum or other informal science learning resource.

Figure 7-20.
Percentage of adults with access to a computer at work or home, by educational level



See appendix table 7-26. *Science & Engineering Indicators – 1998*

Use of New Information Technologies

The 1990s was a period of emergence of electronic media. Over the last decade, individual access to computers at work or at home has increased substantially and steadily. (See "The Use of Computer Technology in the United States.") By 1997, 57 percent of Americans reported using computers at work, at home, or both. (See figure 7-20 and appendix table 7-26.) Fully 88 percent of college graduates in the United States indicated that they used a computer at work or at home, compared to 60 percent of high school graduates and 21 percent of those who did not complete high school. In 1997, two-thirds of the attentive public for science and technology policy reported that they had regular access to a computer at work or at home.

The 1997 results show that Americans do a substantial amount of work on their computers. The average respondent reported spending 369 hours a year using a work computer and 130 hours using a home computer.[17]

A third of Americans have a home computer that includes a modem, and 18 percent report using an on-line or Internet service. (See appendix table 7-27.) Nearly two-thirds of Americans with a graduate degree or professional education have a home computer with a modem, and 41 percent reported that they use an on-line service. Over half of the attentive public for science and technology policy reported that they own a home computer and use it an average of 225 hours per year. Nearly half of this attentive public have a home computer with a modem, and are thus better positioned to make extensive use of the Internet and its information resources.

Twenty-nine percent of Americans indicated that they have a home computer that includes a CD-ROM reader, a technology that opens important new information resources ranging from larger reference works to collections of visual images with sound. The number of government agencies and private organizations

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[17] The hours of computer use by individuals who reported that their place of business was in their home were counted as work hours.

The Use of Computer Technology in the United States

Three new indicators collected for the first time in 1997 illustrate the broad and growing use of computers and computer-based technologies by American adults. First, 43 percent of Americans lived in a household in 1997 with one or more working computers, and 11 percent of Americans reported that they have more than one working computer in their home. (See figure 7-21.) In contrast, in 1983, only 8 percent of American adults had access to a home computer.

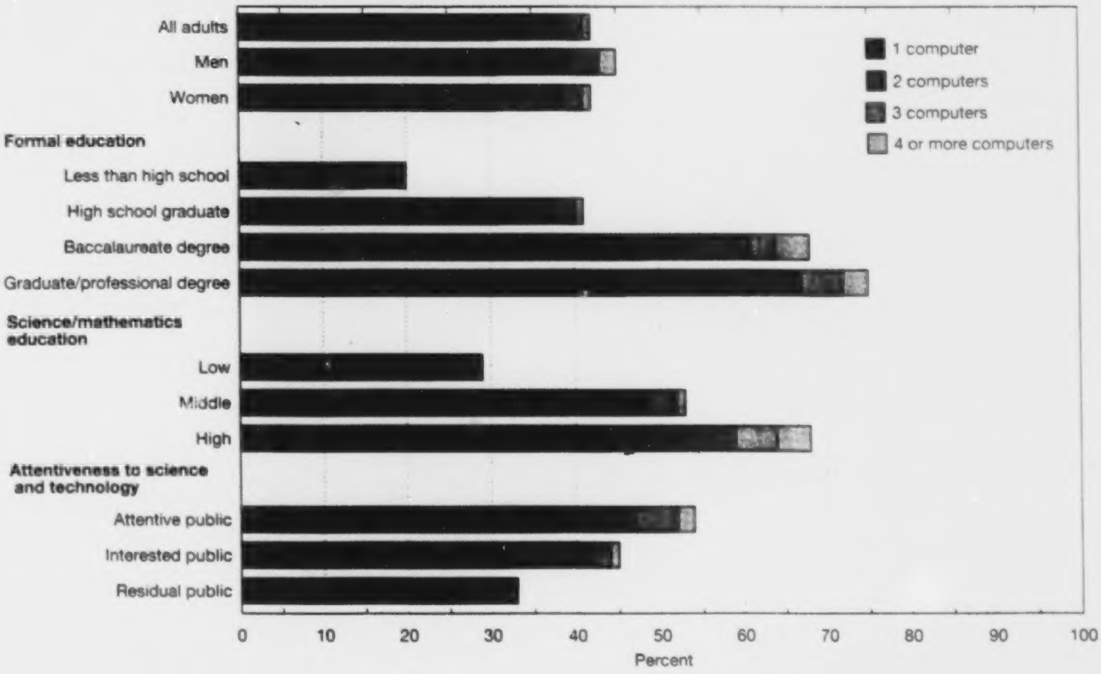
The distribution of home computers and of multiple home computers is strongly related to level of educational attainment. Three-quarters of adults with a graduate or professional degree own a home computer, with 29 percent having two or more working computers in their home. Similarly, 24 percent of individuals with extensive high school and college coursework in science and mathematics reported having two or more working computers in their home, as did 16 percent of the attentive public for science and technology.

Second, approximately 28 percent of Americans have an e-mail address, and 5 percent of U.S. adults—about 9 million individuals—have two or more e-mail addresses. (See figure 7-22.) The multiple e-mail addresses appear to reflect one e-mail address associated with work and a second e-mail address for home or family use.

The distribution of e-mail addresses is strongly related to the level of educational attainment. Slightly more than 60 percent of adults with a graduate or professional degree have at least one e-mail address, and 19 percent have two or more e-mail addresses. A similar pattern is found among baccalaureate-holders, with 55 percent having an e-mail address and 16 percent having two or more e-mail addresses. Furthermore, 60 percent of individuals with extensive high school and college coursework in science and mathematics reported having an e-mail address, as did 42 percent of the attentive public for science and technology.

Third, approximately 16 percent of Americans reported having access to the World Wide Web from their home computer in 1997. To understand how individuals use the Web, all respondents in the *Indicators* study were

Figure 7-21.
Percentage of U.S. adults with one or more home computers: 1997



SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

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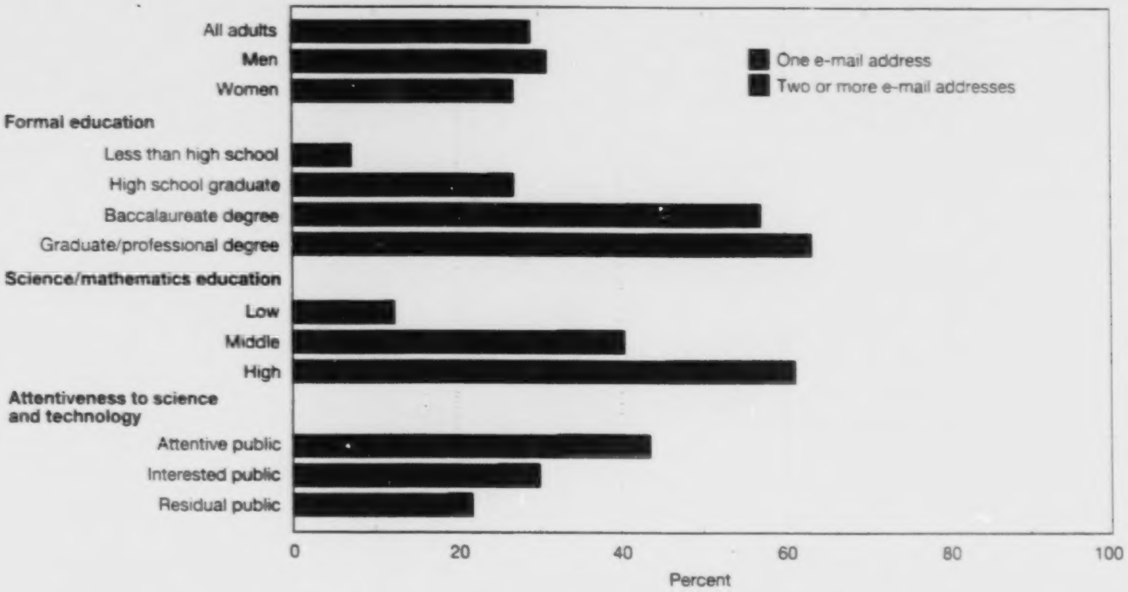
Figure 7-22.
Percentage of U.S. adults with one or more e-mail addresses: 1997



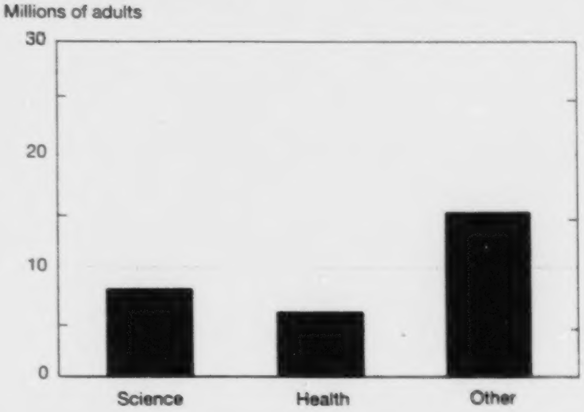
SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

asked if they had tried to obtain any specific information from the Web, or whether they primarily browsed the various sites on the Web. Twelve percent of adults sampled—representing approximately 22 million people—indicated that they had previously tried to find some specific item of information on the Web. This pattern of response indicates that people are using the Web as they might use reference materials in a library.

Each respondent who reported some prior effort to find specific information on the Web was asked to describe in general terms the kind of information that he or she was seeking. An analysis of these responses indicated that approximately 6.5 million Americans had attempted to find some information on the Web about a specific health condition or problem, and approximately 8.8 million had tried to find some scientific information on the Web—including information on the space program, environmental information, and computer information. More than 15 million adults reported that they attempted to find other kinds of specific information on the Web. (See figure 7-23.)

While these results indicate that the vast majority of Americans do not presently use the Web as an information source, the relatively high level of use reported among the first segment of the American population to obtain Web access suggests that it is likely to become a major source of reference-type information in the decades ahead, as the total level of Web access continues to expand.

Figure 7-23.
Estimated number of U.S. adults seeking specific information on the World Wide Web, by subject area: 1997



SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

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that are distributing information in this medium is growing rapidly. As with other electronic media, better educated Americans are the most frequent users of this new technology.

Americans use a wide variety of sources to obtain new information, including information about science and technology. Americans with fewer years of formal education tend to rely on broadcast media, primarily television. College-educated Americans are frequent viewers of both television news and television science shows, but appear to rely more heavily on print media and, increasingly, on electronic information sources.

Summary

Science and technology are subjects of substantial interest to Americans. Using a 100-point Index of Issue Interest, the mean level of interest in new scientific discoveries has increased from 61 in 1979 to 70 in 1997, indicating that science and technology are becoming an increasingly integral part of the American culture. Individuals with more years of formal education and more courses in science and mathematics are more likely to show a high level of interest in science and technology. Comparatively, 70 percent of Americans expressed a high level of interest in medical discoveries and 52 percent indicated that they were very interested in environmental issues, but only 32 percent reported a high level of interest in space exploration.

Despite the high levels of interest, only 19 percent of Americans think that they are very well-informed about science and 16 percent about the use of new inventions and technologies. Americans with more years of formal education and more courses in science and mathematics are significantly more likely to view themselves as being very well-informed than others, and men are significantly more likely to indicate that they are very well-informed about science and technology, holding constant the level of formal education and the level of science and mathematics education.

Using a more objective standard reveals that many Americans have a limited vocabulary of scientific and technical concepts. On a 0-100 scale, the mean score on the Index of Scientific Construct Understanding was 55. This score has remained relatively constant since 1988. Individuals with more years of formal schooling and more courses in science and mathematics obtained significantly higher scores, demonstrating the pervasive effect of science and mathematics education throughout the adult years. Compared to 13 other industrial nations, the mean score for American adults on the Index of Scientific Construct Understanding was tied for first with Denmark, closely followed by the Netherlands and Great Britain.

Only 27 percent of Americans understand the nature of scientific inquiry well enough to be able to make informed judgments about the scientific basis of results reported in the media. Public understanding of the nature of scientific inquiry was measured through questions about the meaning of scientific study and the reasons for the use of control groups in experiments. Individuals who have completed more years of formal schooling and more courses in science and mathematics were significantly more likely to understand the nature of scientific inquiry than other citizens.

Approximately 27 million Americans—14 percent—are attentive to science and technology policy issues, a level that has increased since 1995. In complex modern societies, it is not possible for citizens to become and remain informed about the full range of public policy areas, and some degree of issue specialization is inherent in these societies. About half of Americans indicate that they are interested in and informed about at least one public policy area, and, among those citizens who follow any public policy issues, it appears that most of them follow two or three issues at any given time.

Americans get most of their information about public policy issues from television news and newspapers. When placed on a uniform scale of the number of uses or hours per year, the public consumption of television news and newspapers dwarfs all other information sources. In 1997, Americans watched an average of 432 hours of television news and read 196 newspapers. During that period, Americans watched 72 hours of television science programs. Individuals with cable or satellite TV service watch more science television programs than those without this service.

Fifty-seven percent of Americans use a computer at home or at work, and computer use has increased steadily during the last decade. In 1997, Americans used a computer at work for 369 hours and used their home computer for an additional 130 hours. A significantly higher proportion of college graduates use a computer than individuals with fewer years of schooling.

In 1997, nearly one-third of Americans had a home computer that included a modem, and 18 percent of adults reported that they had used an on-line computer service during the preceding year. This is a significant increase in home access to on-line resources in the last two years alone. Moreover, 29 percent of adults in the United States reported having a home computer with a CD-ROM reader, opening additional information acquisition opportunities. Nearly two-thirds of Americans with a graduate or professional degree have a home computer with a modem, and 41 percent reported that they use an on-line service.

Americans continue to hold the scientific community in high regard. According to the most recent General Social Survey in 1996, approximately 40 percent of Americans expressed a great deal of confidence in the leadership of the scientific community and in the leadership of the medical community. This confidence has been stable for nearly two decades and is far higher than the levels reported for the leadership of most other major societal institutions.

Americans have high levels of belief in the promise of science and technology, with an average score of 70 on a 0-100 scale. They hold low levels of reservation about science and technology, with an average score of 37. These levels of reservation are the lowest reported among citizens of industrial nations. Compared to the citizens of 13 other industrial nations, Americans registered a strong belief in the promise of science and the lowest level of reservation about science and technology.

Seventy-five percent of Americans believe that the benefits of scientific research outweigh any present or potential harms. This level of positive assessment of scientific research has been stable for nearly two decades and reflects the high esteem in which the public holds the scientific community. College graduates and citizens attentive to science and technology policy hold even more positive views of science.

Despite their positive views of scientific research, Americans are deeply divided over the development and impact of several important technologies. They are relatively evenly divided on the benefits and harms of using nuclear power to generate electricity, and this division has persisted for more than a decade. A similar division occurs over the benefits and potential harms of genetic engineering, but there is a clearer difference by level of education, with college graduates holding much more positive views of genetic modification research. Regarding the space program, a small plurality of the general public believes that the benefits of the space program exceed its costs. College graduates and the attentive public for space exploration have continued to hold very positive attitudes toward the space program throughout the last decade.

Overall, the American public appears to continue to expect science and technology to improve the quality of life, and the scientific community is accorded a higher level of trust and confidence than other major societal institutions. Nonetheless, the concerns regarding several specific technologies indicate that the public has not given the scientific community a blank check. The public wants to know what is happening, and the scientific community needs to communicate its work ever more clearly and effectively.

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Chapter 8
Economic and Social Significance of Information Technologies

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Highlights

IT AND THE ECONOMY

- **The use of information technologies (IT) is pervasive in the United States.** The real net computing capital stock in the private sector was $155.8 billion in 1995. And, in many industries, the number of employees who use a computer at work is more than 50 percent; in the banking industry, it is 85 percent.
- **IT is believed to have contributed to the country's structural shift to a service economy.** In the United States, growth in services as a proportion of gross domestic product has been led exclusively by IT and knowledge-intensive industries such as finance, insurance, real estate, and professional services.
- **The U.S. Bureau of Labor Statistics projects employment in IT-producing industries to nearly double from 1986 to 2006.** This expansion is due almost entirely to growth in computer and data processing services (including software manufacturing); employment declines are projected for the IT hardware industries. Since precise projections are always difficult, this should be taken as a general direction, not an exact level of employment.
- **Several comprehensive studies, using a variety of data and methods, indicate that there is an overall skill upgrading taking place in the labor force,** a trend attributed to the greater use of IT in many occupations.
- **The incidence of IT-related injury and employee surveillance in the workplace are on the rise,** but impacts on individuals are uncertain.
- **Recent research suggests—unlike past evidence of a "productivity paradox"—that there may be measurable productivity gains from IT.** Nonetheless, it is difficult to predict the precise organizational and firm-level conditions that foster the effective use of IT.

IT AND EDUCATION

- **By 1992, 80 percent of all K-12 schools had 15 or more microcomputers for instruction. In 1996, 85 percent of all schools had access to multimedia computers, 65 percent had Internet access, and 19 percent had a satellite dish.** Internet linkages are not necessarily widely accessible within schools—in 1996, only 14 percent of instructional classrooms had an Internet hook-up.
- **In fifth grade, more than half (58 percent) of the instructional use of computers is for teaching academic subject matter.** By 11th grade, less than half (43 percent) of computer-based instruction is for content; 51 percent is for computer skills training.
- **Meta-analyses of educational studies conducted between the late 1960s and the late 1980s consistently reveal positive impacts of computer-based instruction at the K-12 level.** Estimates of the order of magnitude vary, but one meta-analysis of 40 studies gave evidence of learning advantages that ranged from the equivalent of one-third to one-half of a school year for K-6 education.
- **The cost effectiveness of computer-based instruction relative to other forms of instruction has not been demonstrated.** As pressures to increase IT spending grow, it is likely that school districts will face greater opportunity costs between IT and other education-related expenses.
- **There is significant educational inequity in access to computers and the Internet.** Schools whose student body is represented primarily by minority or economically disadvantaged students have one-third to three times less access to these technologies than do schools attended primarily by white or nondisadvantaged students.
- **Poor and minority students cannot compensate for less computer access at school in their homes.** In 1993, blacks and Hispanics had half as much ownership of home computers as whites. The poorest and least educated groups had about one-tenth the access to home computers as the most affluent and educated groups. Research indicates that when the "informationally disadvantaged" are given access to computers and the Internet, they use these resources effectively for self-empowerment.

IT AND PRIVATE CITIZENS

- **Concerns about information privacy are growing larger and stronger.** In a 1996 Equifax/Harris privacy survey, two-thirds of the respondents said that protecting consumer information privacy was very important to them.
- **The vast majority of Americans believe that companies should be prohibited from selling information about consumers**—including their income, bill-paying history, and product purchases—and that stiff restrictions should be placed on access to medical records. Unfortunately, most Americans also believe that they have already lost control of personal information about themselves.

Introduction

Chapter Overview

The revolution in information technologies (IT) has been likened to the industrial revolution in terms of its potential scope and impact on society (Alberts and Papp 1997; Castells 1996; Freeman, Soete, and Efendioglu 1995; and Kranzberg 1989). With the exception of electrification, no other modern advances in technology have had the capacity to affect so fundamentally the way people work, live, learn, play, communicate, and govern themselves. Indeed, some social philosophers expect that IT might affect the nature of what it means to be human—changing values, emotions, and cognitive processes.

Science & Engineering Indicators – 1998 attempts to benchmark certain dimensions of the growing role of information and information technologies in American society. At present, there is little systematic data on either the diffusion of IT or its impacts on society. Metrics are confounded by both the fuzziness of IT as a concept and the interactive effects of so many social variables—including age, ethnicity, income, learning processes, individual attitudes, organizational structures, and management styles. In addition, the rate of technological change since the early 1980s has often outpaced our ability to define what it is we want to know and what data ought to be collected.

As a consequence, this chapter focuses on three core areas where the analytical questions have stabilized and where there is a large body of existing research:

- the role of IT in the national economy;
- the influence of IT on K-12 student learning; and
- the impact of IT on citizens, particularly with respect to equity and privacy.

Each of these areas illustrates the ways in which science-based technology can have profound social consequences (both positive and negative) and the difficulties in defining, measuring, and tracking a technology that is still emerging.

Three generalizations can be made about the state of our empirical understanding of IT's effects on society. First, quantitative indicators of IT diffusion are relatively abundant but not necessarily regularly updated. Second, indicators of the actual effects of IT on individuals, institutions, and markets are extremely difficult to establish. Currently, statistical studies in many areas of interest are both nonrepetitive and noncumulative; that is, studies do not necessarily use the same methodologies (thus generating different statistics) and do not build on one another (findings from one study are not verified and expanded on in others). This state of affairs has less to do with the quality and rigor of the research than with the complexity and dynamism of IT as a subject of study. Moreover, experts have not determined how to measure some elements of considerable interest, such as productivity in some service industries.

Third, the state of existing research makes it difficult to draw any definitive conclusions about the impacts of IT on society. For example, evidence exists of both increased and decreased productivity, as well as of both a lowering and an upgrading of skills in the labor force. Both positive and negative consequences may also be found. For example, computer-aided instruction may clearly enhance some forms of student learning, but extensive use of some computing environments may interfere with aspects of child development. Positive effects (such as enhanced business performance or student learning) are often highly contingent upon the presence of a number of other factors, such as appropriate organizational structures, managerial style, the adequacy of teacher training, and the attitudes of the individual using IT. All that may be said definitively about IT's social and economic impacts is "it depends": both on how we have measured and modeled the subject of study, and on the all-too-human conditions surrounding its use.

The evidence and indicators presented in this chapter do cohere as a somewhat sketchy image of the social and economic impacts of IT as of the mid-1990s. The predominant feature reflects the scope and presence of IT in the economy, schools, and the home. In many industries, the level of computer use (as measured by the number of employees with computers on their desktop) exceeds 50 percent. More than 70 percent of large firms in key manufacturing sectors (such as machinery, electronics, and transportation) use computer-aided design and/or numerically controlled machine tools. In addition, many services (such as automated banking, credit card sale authorization, express delivery, and electronic commerce) could not exist in the absence of an IT infrastructure.

Elementary and secondary schools have similarly high rates of IT adoption. By the early 1990s, 80 percent of all K-12 schools had 15 or more instructional computers, and the national median number of students per computer was 14—essentially one computer per classroom. Less pervasive is access to the Internet in schools; in 1996, only 14 percent of the instructional classrooms nationwide were linked to the Internet. At the household level, roughly one-quarter of all homes had a personal computer (PC) in the early 1990s; these households were disproportionately wealthy and white. As discussed in several sections of this chapter, IT is not necessarily ubiquitous, and schools and homes reflect a real inequality in access to computers and other information technologies.

The effects of IT are most clearly visible at the "micro" level—that is, the level of the individual firm, classroom, household, etc. For example, the strongest indicators of economic enhancements from IT are seen with firm-level data sets and for impacts that reflect improvements in firm-level activities (such as transaction processing time, product quality, cycle times, and customer service and convenience). The measurable learning effects of computer-based instruction (CBI) are most pronounced for the elementary grades and for rote learning; computer-enhanced higher order thinking skills are harder to demonstrate, perhaps because of a lack of appropriate software, but also because of the greater emphasis on building computer skills in secondary school rather than on content learning.

Chapter Organization

This chapter begins with a discussion of the nature of information technologies and the issues involved with measuring the effects of IT on society. Subsequent sections address (1) the role of IT in the economy, (2) the effects of IT on K-12 education, and (3) IT and the citizen. The final section addresses the need for better IT metrics.

Information Technologies

IT reflects the fusion of two key technological changes: the development of digital computing and the ability to transmit digital signals through telecommunications networks. The foundation of all information technologies and products is the ability to represent text, data, sound, and visual information digitally. By integrating computing and telecommunications equipment, IT offers the ability to access stored (or real-time) information and perform an extraordinary variety of information-related tasks.

IT does not represent a single technology as much as it does systems of interactive technologies used for information processing. There are literally hundreds of commercial products—ranging from telephones to supercomputers—that can interact in an information processing system. The distinctly different functions of many of these products contribute to a sense of fuzziness about IT's technological boundaries. Keen (1995) suggests, however, that IT can essentially be grouped into four basic technological elements of information processing:

- tools to access information,
- telecommunications linkages (including networks),
- information processing hardware and software, and
- storage media.

Figure 8-1 illustrates the more common technologies that are used for each of these elements and reinforces the understanding of IT as an interactive system of multipurpose technologies rather than a single class of products.

The rapid social and economic diffusion of IT since 1980 has been stimulated by threshold technical changes in computing power, applications, telecommunications, and networks as well as concurrent reductions in the cost of technology. Text table 8-1 illustrates advances in computing power (measured as million instructions per second) that have occurred since the introduction of the first microprocessor, while text table 8-2 presents trends in the relative cost of this power for popular commercial microprocessors. Notably, the computer price deflator calculated by the U.S. Department of Commerce has declined more than fortyfold since 1977 (Warnke 1996).

The other key development in IT is the growing connectivity of computers and information—and, by logical extension, people. Computerized data exchange is the basis for automated teller machine (ATM) transactions, credit card authorizations, airline reservation systems, electronic commerce, and overnight delivery services. A more advanced system, electronic data interchange, is becoming a standard form of communication between suppliers and customers to streamline ordering, purchasing, distribution, and billing operations. The extent of this growing networking is evident in the diffusion indicators—one study estimates that the number of installed local area networks was just over 1 million in 1981, about 12 million in 1990, and close to 40 million in 1995 (Morrison and Schmid 1994).[1] Use of the World Wide Web, a subsystem on the Internet (see "History of the Internet"), exploded with the introduction of the Mosaic search engine

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[1] Local area networks are devices (computers, telephones, security systems, automated cash registers, etc.) connected into an information network, typically in a single building or very small geographic area.

Figure 8-1.
Technological components of an information processing system

Devices to access information

- Computers
- Telephones
- Scanners
- Smart cards
- TVs
- Automated teller machines (ATMs)

Telecommunications links

- Radio wave
- Telephone line
- Coaxial cable
- Fiber optic
- Satellite
- Cellular

Information processing

- Computer hardware
  - -mainframes
  - -minicomputers
  - -microcomputers
- Software
  - -decision support systems
  - -data visualization
  - -hypermedia
  - -business and home applications
  - -expert systems

Storage media

- Hard drive
- Zip™ drive
- Floppy disk
- CD-ROM
- CD read/write
- Mag tape

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Text table 8-1.
Trends in computing power

	Micro-processor	Transistors (thousands)	Million instructions per second	Word size (in bits)
1971	4,004	2.3	0.06	4
1974	8,080	6	0.64	8
1978	8,086	29	0.75	16
1982	80,286	134	2	16
1985	80,386	275	6	32
1989	80,486	1,200	20	32
1993	Pentium	3,100	100	32
1995	Pentium Pro	5,500	250	64

SOURCE: F. Moris, "Semiconductors: The Building Blocks of the Information Revolution," *Monthly Labor Review* (August 1996): 6-18.

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Text table 8-2.
Trends in computing price relative to speed

	Device	Million instructions per second	Price per million instructions per second ($)
1975	IBM Mainframe	10	1,000,000
1976	Cray 1	160	125,000
1979	DEC VAX	1	200,000
1981	IBM PC	0.25	12,000
1984	Sun 2	1	10,000
1994	Intel Pentium Micro	66	3,000

SOURCE: J. Warnke, "Computer Manufacturing: Change and Competition," *Monthly Labor Review* (August 1996): 18-30.

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in 1993. Market experts estimate that the Web had 69 million users in 1997 and about 80,000 servers; by 1996, about half of all U.S. companies had sites on the Web (IDC 1997).

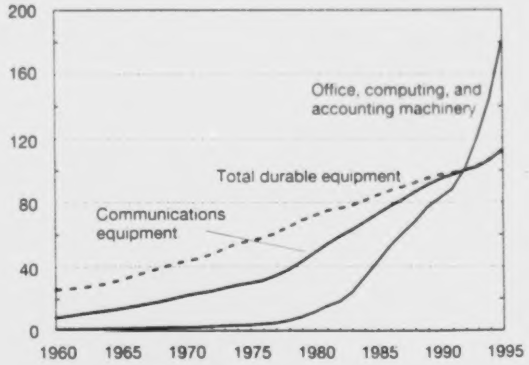
The Information Society

The development, diffusion, and consequences of IT are part of a larger context: that of the "information age" or "information society." What exactly these concepts mean is uncertain, as they are not consistently used or explained in scholarly and popular discussions of the emerging information revolution.[2] In an extensive review of writings about the information age, Webster (1997) concludes that it has five distinct analytical dimensions: technological, economic, occupational, spatial, and cultural.[3] While not all analysts agree that human civilization is undergoing an information revolution, there is a pervasive sense that "information and communications will become the dominant forces in defining and shaping human actions, interactions, activities, and institutions" (Alberts and Papp 1997, p. 1).

The present amount, variety, and accessibility of information within American society is unprecedented. Indicators of the economic and social diffusion of IT reveal that the technological capacity for information consumption has increased dramatically in the United States. The volume of IT is most substantial in the economic sector, where the real net computing capital stock was 200 times greater in 1995 than it was in 1975, and the real net communications equipment capital stock was five times greater than in 1975.[4] (See figure 8-2.) In many industries, the number of workers who use a computer at their job now ranges from 50 to 85 percent (for more detail, see "Impacts of IT on the Economy"). In the manufacturing sector, U.S. Census data indicate that by the late 1980s, 83 percent of firms with 500 or more employees in the metals, machinery, electronics, transportation, and instrument industries used computer-aided design; 70 percent used numerically controlled machine tools (Berman, Bound, and Griliches 1994).

Extensive diffusion of IT is likewise found in the education sector. By 1985, more than three-quarters of all elementary and secondary schools had at least one microcomputer for student instruction. By 1992, all K-12 schools had at least one instructional microcomputer, and 80 percent had 15 or more computers. (See figure 8-5.) The median number of students per computer correspondingly declined from 42 in 1985, to 20 in 1989, to 14 in 1992—essentially the equivalent of one computer per

Figure 8-2.
Real net stock of IT equipment in the private sector
(Chain-type index, 1992 = 100)



NOTES: Total durable equipment is nonresidential equipment. Chain indices are new constant value indices developed by the U.S. Bureau of Economic Analysis. IT is information technologies.

See appendix table 8-2. *Science & Engineering Indicators – 1998*

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[2] For a thorough and up-to-date treatment of many of the issues surrounding the concept of the information society, see Alberts and Papp (1997).

[3] The cultural dimension includes education, governance, religion, values and ethics, and popular culture.

[4] In 1995, the total net capital stock of office, computing, and accounting machinery was $155.8 billion; for communications equipment, it was $388.5 billion (in current dollars). See U.S. BEA (1997), pp. 79-81.

History of the Internet

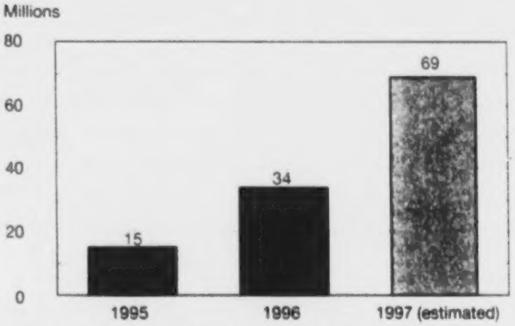
For many Americans, nothing epitomizes IT as much as "the Net." The Internet is a meta-network for a variety of subnetworks and applications such as the World Wide Web, bulletin boards, Usenet newsgroups, e-mail, scientific data exchange, and more.

The foundation for the Internet was ARPANET, a network that started as four computer nodes in 1969. ARPANET was initiated by the U.S. Defense Advanced Research Projects Agency, and was based on a then-new telecommunications technology called "packet switching." ARPANET flourished as a medium for information and data exchange among universities and research laboratories. Moreover, it stimulated the development of TCP/IP, a communications protocol distributed with the UNIX operating system which has now become the standard for the Internet and other types of commercial telecommunications. By the late 1970s, ARPANET represented hundreds of computer nodes and had integrated several separate computer networks, including one based on satellite technology.

The "real" Internet resulted directly from the National Science Foundation's (NSF's) sponsorship of CSNET, and later, NSFNET (a high-speed network funded by NSF to link its supercomputing centers). NSFNET replaced ARPANET in 1990 and expanded to include a variety of regional networks that linked universities into the backbone network. Large numbers of smaller networks quickly linked into NSFNET—albeit without any planning, control, management, or security. By early 1994, commercial networks became widespread; almost one-half of all registered users of the network were commercial entities. Additionally, the amount and variety of information carried by NSFNET escalated.

Two related events dramatically reshaped the character of the Internet. First, scientists at the European Center for Particle Research (CERN) developed the World Wide Web and introduced it in experimental form in 1989. Second, in 1993, a team of programmers at NSF's National Center for Supercomputing Applications at the University of Illinois introduced Mosaic, a graphical (hypermedia) browser for exploring the Web. Because Mosaic was free and available to the public on the Internet, use of the Web (via Mosaic) soared. The number of Web users doubled annually from 1993 to 1996, and was estimated to be 69 million worldwide in 1997. (See figure 8-3.) Netscape, the leader in commercial Web browser software (accounting for 70 percent of the market), reported that in mid-1997, about 600,000 new users *per week* were accessing its software (NUA Ltd. 1997). And, compared to other countries, the United States has more Internet servers per capita than any other nation except Finland. (See figure 8-4.)

Figure 8-3.
Number of World Wide Web users



SOURCE: International Data Corporation, "New Priorities and Technologies for the Year Ahead," <<http://www.idcresearch.com/BS97/111.htm>> (June 1997).

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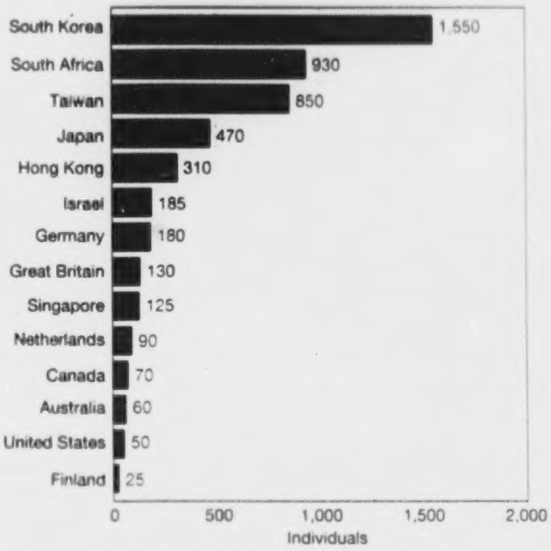
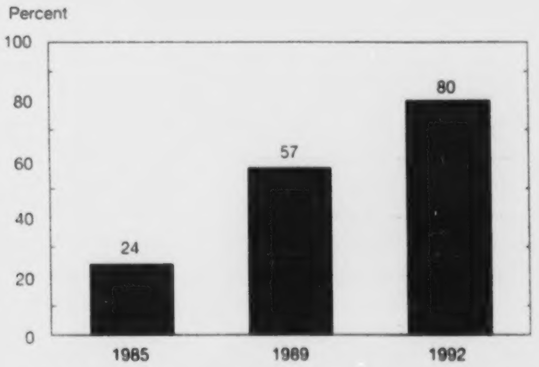
Figure 8-4.
Number of individuals per Internet server, for selected countries: 1996



SOURCE: M. Martin, "When Info Worlds Collide," *Fortune* October 28, 1996: 130-33. *Science & Engineering Indicators – 1998*

NSFNET was decommissioned in 1995, when there were enough commercial Internet service providers, Web browsers, and search engines to sustain the network's operations and management; the Internet is now fully privatized. After transforming from ARPANET to NSFNET to the Internet, the next stage of evolution is the "information superhighway"—a telecommunications infrastructure that would allow *all* national public networks and education and research institutions to link with one another at higher speeds than today. Promoted first by the federal National Information Infrastructure Initiative, and now by the Next Generation Internet Initiative, the new information superhighway will be a higher speed, more functional telecommunications network. For more information on the Internet, see Keen (1995) and Cerf (1997).

Figure 8-5.
Percentage of elementary and secondary schools with 15 or more computers



SOURCE: U.S. Bureau of the Census, *Statistical Abstract of the United States 1996*, table 262 (Washington, DC: U.S. Government Printing Office, 1996); data based on the Computers in Education Study conducted by the International Association for the Evaluation of Educational Achievement.

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classroom.[5] As addressed in the last section of this chapter, educational access to computers and other IT is not equitable in terms of race, ethnicity, or income.

Use of computers in the home lags behind the economic and education sectors. U.S. Bureau of the Census (1993) data indicate that although the number of homes with a computer nearly tripled from 1984 to 1993, this amounted to only 23 percent of all households by 1993. Household use is clearly linked to income and ethnicity. Nearly twice as many adult whites had a computer at home in 1993 as did blacks (27 versus 14 percent, respectively); and 62 percent of all households with incomes of $75,000 or more had a computer—double the rate of households with incomes of $35,000 to $49,999 and well over triple the rate of lower income groups. (More detail on the significance of ethnicity and class is discussed later in "Equity Issues.") The comparatively low level of access to home computers in the early 1990s may be changing quickly, however. Data discussed in chapter 7 indicate that 43 percent of adults in a 1997 survey have a computer at home. (See appendix table 7-26.) In addition, a number of PCs priced less than $1,000 were commercially introduced in 1997, and 80 percent of PC shipments are now expected to be for the home market (Pargh 1997 and IDC 1997).

Determining the social and economic effects of this growing use of IT in society is complicated. First, the scope of such effects—both positive and negative—is immense. For example, over a decade ago, Michael Marien (1986) of the World Future Society compiled and categorized 125 expected effects of IT, ranging from the individual to the international system. Second, many types of effects are hard to measure—such as productivity in the service sector or the psychological, emotional, and cognitive impacts of prolonged exposure to computing environments. As discussed in the next section, it is easier to measure and develop indicators for the diffusion and uses of IT in society than it is to isolate and examine the consequences of that use.

Issues in Measurement and Research

The measures and indicators used here are unlike those found in other chapters of this volume in several ways. First, data on IT are rarely collected on a systematic basis. Accordingly, there are no extensive time-series data on IT diffusion and its effects—the type of indicators available reflect ad hoc interests rather than ongoing analytical needs. (Two notable exceptions are the time-series data on IT investments and capital stock reported by the U.S. Bureau of Economic Analysis and the data on IT in schools collected by Quality Education Data, Inc.) Second, IT as a concept is not clearly defined, and available data are frequently not comparable. In contrast, such indicators as research and development (R&D) expenditures and scientists and engineers are both well-defined and clearly documented not only in the United States, but in the international community as well.

Third, some subjects of interest have not been quantified, such as labor productivity for several key IT industries, including computing and data services. Fourth, it is often extremely difficult to isolate the effects of IT from other factors, such as industrial deregulation; management practices; employee attitudes; and the myriad conditions affecting student learning and achievement: individual ability, teaching skill, classroom environment, nutrition, affinity for the subject matter, and so on. Fifth, there is a time factor. The effects of a technology on human behavior may take years to show up and often may be reliably detected only through controlled, longitudinal study of a set of individual subjects. Finally, much insight on the effects of IT comes from case studies—a useful form of analysis but one that cannot be used to generalize to a larger group or population.

When new areas of inquiry emerge in the social sciences (such as the social and economic impacts of IT), it can take years to develop a dominant "heuristic" (models, theories, and methods) with which to organize research and empirical findings. The field of study surrounding the social and economic impacts of IT is consequently characterized by the full spectrum of social science research methods and techniques. Research and analyses range from qualitative (the use of historical analysis, guided observation, case studies, pattern matching, metaphors, and other narrative information) to quantitative (controlled experiments, cross-sectional or longitudinal data collection and analysis, survey research, content analysis). In all instances, the objective is to determine patterns of regularities in human behavior and the causes of those patterns.

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[5] See U.S. Bureau of the Census (1996), table 262. Data are based on the Computers in Education Study conducted by the International Association for the Evaluation of Educational Achievement.

Two "decision rules" were used when evaluating research for inclusion in this chapter:

- Diffusion indicators had to be obtained through valid and representative sampling methodologies. In some instances, data from leading market research companies were used, even though detailed information on sampling methods was not available; these firms (such as International Data Corporation) are considered reputable and reliable sources of IT market data.
- Empirical studies had to use valid statistical analysis and sampling methods (when appropriate), control for non-IT factors, and be representative of the group or sector under study. Qualitative studies had to follow an explicit research design and be consistent with other narrative and descriptive information.

Diffusion indicators are relatively abundant because they can be easily obtained through conventional survey methods, and there is considerable commercial interest in the demographics of the IT market. Economic effects have been widely studied, but empirical research frequently tends to result in contradictory findings. Quantitative research on the effects of IT on student achievement is extensive (bibliometric searches yield thousands of citations), but diverse research designs make it extremely difficult to cumulate findings. The educational findings discussed here are the results of "meta-analysis," a technique used for integrating multiple studies (this technique is discussed more in the section on "IT, Education, and Knowledge Creation"). Judgments about the impact of IT on equity and privacy are largely inferred from descriptive data and qualitative analysis because of the difficulties in quantifying political power and levels of individual privacy.

Impacts of IT on the Economy

Diffusion of IT has had significant effects on business activity. Computer-integrated manufacturing, for example, enables automated model changes on the production line as well as fully integrated design and manufacture. Resulting shortened cycle times and the declining significance of economies of scale have led to a competitive environment that focuses on quality, customization, and timeliness of delivery. Firm-level IT networks ("intranets") integrate finance, manufacturing, R&D, operations, and marketing, and have fostered the rise of strategic management in industry. The IT-based integration of producer-supplier and wholesaler-retailer networks enables responsiveness to daily changes in customer demand and a fundamental revolution in inventory management. Advanced telecommunications technologies have integrated international capital markets and literally created a global financial industry. In short, IT has moved economic markets and business behavior far closer to "real-time" mode than has ever existed in the past.

Yet in almost all instances, the precise economic impacts of these effects cannot be quantified, and there is often contradictory evidence about the role of IT. For example, research (reviewed below) shows that IT has contributed to both deskilling and skill upgrading in the workplace, although the trend appears to be toward upgrading. Until very recently, the empirical record demonstrated that, in spite of the enthusiastic adoption of IT by business, IT has had little observable impact on productivity growth in the United States (a paradox explored further below).

This section summarizes quantitative indicators of the economic effects of IT in three core areas of interest:

- the structure of the economy,
- employment and workers, and
- the "productivity paradox."

The findings indicate that IT has diffused unevenly throughout the economy and that the net impacts on employment and productivity are uncertain—at least as traditionally measured.

Economic Growth and the Service Economy

IT contributes to macroeconomic output in a variety of ways. For example, IT can create better ways of generating goods and services, improve production efficiencies, and increase both labor and multifactor productivity. Growth accounting[6] studies confirm IT's positive impact on total U.S. economic output; estimates of the total contribution of IT to the real U.S. growth rate range from 0.16 to 0.52 percent (Jorgenson and Stiroh 1995, Oliner and Sichel 1994, and Sichel 1997).

IT is commonly credited as being a key reason for the structural shift from manufacturing to services in the U.S. economy. Rapid growth in existing services, such as banking, and the creation of new industries, such as software engineering, are attributed to the widespread diffusion of IT in the service sector infrastructure (NRC 1994a, and Link and Scott 1998). From 1959 to 1994, the service sector grew from 49 to 62 percent of U.S. gross domestic product (GDP), while manufacturing declined from 28 to 17 percent.[7] (See figure 8-6 and appendix table 8-3.) In the past three decades, growth in services has, on balance, exceeded growth in every other industrial sector—agriculture, mining, construction, and manufacturing.

The expansion of the service sector has been driven entirely by industries that are often classified as "knowledge" industries (see Machlup 1962)—finance, insurance, and real estate (FIRE)—as well as a number of professional services,

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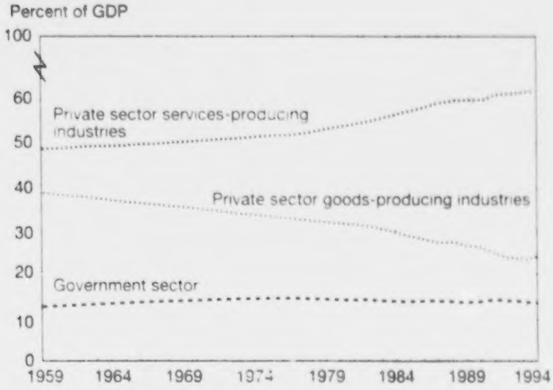
[6] Most output and productivity studies use what is known as a "production function" model. The resulting statistics are typically least-squares correlations and estimates based on a log-linear regression. Growth accounting, a technique developed by Denison (1985), principally uses an arithmetic/algebraic procedure on national income accounts data. Robert Solow received the Nobel Prize in economics for his estimates of the contribution of technical change to aggregate productivity using a production function model (Solow 1957). For more detail on these models, see NSB (1996), chapter 8.

[7] Note that these figures differ somewhat from those frequently published; this is because the U.S. Bureau of Economic Analysis recently revised its methodology for calculating the contribution of specific industries to GDP. See U.S. BEA (1996).

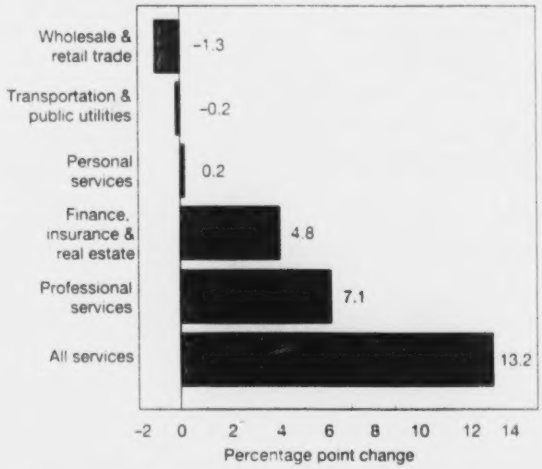
Figure 8-6.
Sectoral shares of U.S. GDP



NOTE: Services-producing industries consist of transportation and public utilities (including communications); wholesale trade; retail trade; finance, insurance, and real estate; personal and professional services; and other services. Goods-producing industries consist of agriculture, forestry, and fishing; mining; construction; and manufacturing.

See appendix table 8-3. *Science & Engineering Indicators – 1998*

Figure 8-7.
Change in share of U.S. GDP, by type of service industry: 1959-94



NOTES: Transportation and public utilities category includes communications. Professional services category includes business, health, legal, educational, social, and miscellaneous.

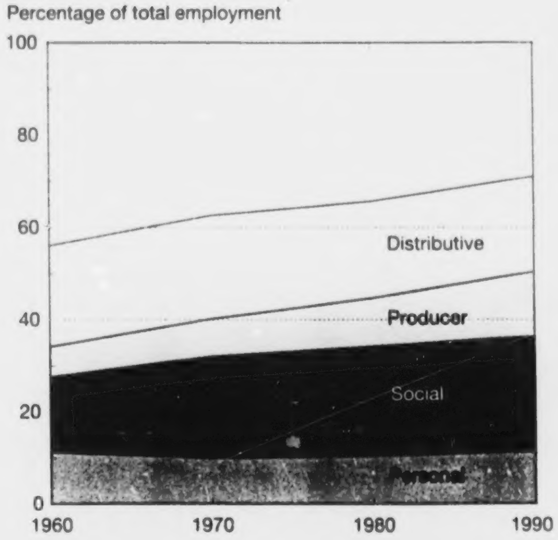
See appendix table 8-3. *Science & Engineering Indicators – 1998*

such as health and education. The share of GDP accounted for by wholesale and retail trade actually declined from 1959 to 1994, while personal services and transportation and utilities remained essentially unchanged. (See figure 8-7.) In contrast, FIRE's share of GDP grew by 4.8 percentage points, while that of professional services increased by 7.1 percentage points. Employment data reflect the same structural shift in the economy as GDP data. From 1960 to 1990, employment in the service sector grew from one-half to two-thirds of total U.S. employment, with growth strongest in producer services (FIRE and professional services) and social services, particularly health care. (See figure 8-8.)

IT has not, however, been empirically linked in any definitive way to the expansion of the service sector. In a detailed study of several key service industries (banking, insurance, air transport, and telecommunications), the National Research Council concluded that although the benefits of IT for individual industries could be qualitatively described, IT could not be causally linked to gross product output of the individual industry for methodological reasons (NRC 1994a).[8] Two observations are worth making, however. First, based on case study evidence and expert reviews, it is unlikely that the expansion of the air transport, banking, finance, and trade industries would have been as significant in the absence of IT (NRC 1994a). In this sense, IT acted as a technological precondition for growth in many service industries.

Second, IT is unevenly distributed throughout the economy and is particularly concentrated in the service industries that have experienced rapid expansion. This suggests that IT is instrumental to the delivery of many services, and that growth

Figure 8-8.
Changing share of U.S. service industries in total U.S. employment



NOTE: Social services include health, education, and nonprofit. Producer services include finance, insurance, real estate, and professional services. Distributive services include transportation, communication, and wholesale and retail trade.

See appendix table 8-4. *Science & Engineering Indicators – 1998*

in services fuels demand for IT (and vice versa). For example, only 14 percent of workers use computers in agriculture, but 85 percent do so in banking and finance. (See figure 8-9.) Investments in IT similarly vary among industries. For example, the communications industry invests five times as much in IT as would be expected given the size of this sector relative to overall GDP. (See figure 8-10.) The disparity in the relative presence of IT among industries indicates that IT is clearly more critical for some types of business activities than others, and thus may be said to be responsible—in part—for the growth of those industries.

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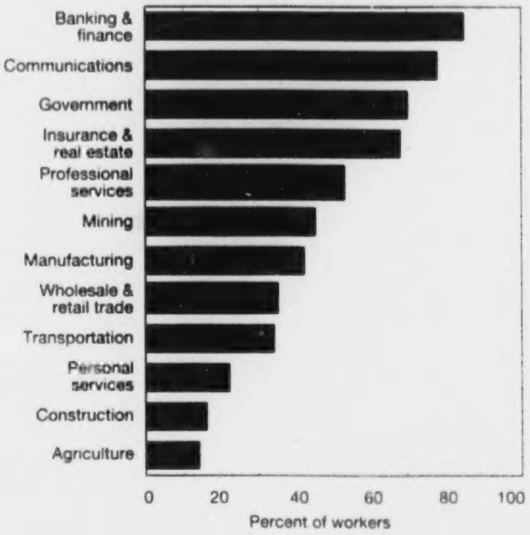
[8] Specifically, IT investment impacts in the 1980s cannot be isolated from the effects of many market, industry, and economic factors such as the deregulation of banking, telecommunications, and air transport.

IT and Employment

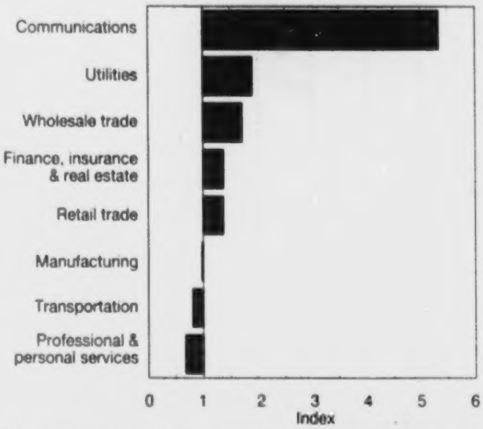
IT has demonstrable benefits for employment and skill levels, although not unequivocally so. Evidence indicates that IT contributes to growth in demand for labor, as well as an overall skill upgrading in the workplace. Computerization of the workplace appears to have enlarged the wage gap between workers with a college education and those with a high school education or less. With respect to the impact of IT on individual workers' health and emotional well-being, the record is mixed. While the number of IT-related health disorders is clearly on the rise, trends may be in part a socio-psychological phenomenon. Computerized surveillance and monitoring of employees may lead to greater stress and alienation in the workplace, but not necessarily: evidence suggests that IT may increase workers' sense of worth, accomplishment, and job autonomy.

Figure 8-9.
Percentage of workers who use a computer at work, by selected industry: 1993



See appendix table 8-5. *Science & Engineering Indicators – 1998*

Figure 8-10.
Index of IT investments, by industry: 1991-92



NOTE: Index represents industry's percentage share of information technologies (IT) investments relative to industry's share of GDP. An index of 1.00 reflects no over- or under-investing in IT relative to the size of the industry. Investments in IT are for hardware only.

See appendix table 8-6. *Science & Engineering Indicators – 1998*

Aggregate Employment

Establishing the net effect of IT on aggregate U.S. employment is difficult for one primary reason: IT is both labor-creating and labor-saving. As new jobs are created in some industries and occupational classes, they are lost in others. For example, banking employment has declined by 100,000 workers since its peak in 1990; analysts attribute this trend in part to the growing use of ATMs (Morisi 1996). IT-driven employment losses are, however, also offset by employment expansion in new industries such as computer and data processing services. Isolating the employment effects of IT from other factors—such as business cycles, industry conditions, and labor mobility—is problematic.

In an evaluation of the research on employment impacts of technology, the National Academy of Sciences concluded that the displacement effects of IT were indeterminate, and depended heavily on conditions in individual firms and industries. Because the nature of the research was so varied and the findings often contradictory, the Academy concluded that

> the contrasting results of these studies…illustrate the sensitivity of empirical estimates of the employment impacts of [IT] to detailed assumptions concerning diffusion rates, technological improvement, and the organization of manufacturing and production processes (Cyert and Mowery 1987, p. 292).

Employment trends in key IT-related sectors further illustrate the difficulty of establishing the overall employment effects of a new technology. Employment in IT-producing industries is projected to nearly double from 1986 to 2006. (See text table 8-3.) Yet this trend is driven almost exclusively by growth in computer and data processing services (including prepackaged software), the third fastest growing industry

Text table 8-3.
Employment in information technology-producing industries
(Thousands)

SIC code/industry		1986	1996	2006
Total		1,963	2,450	3,778
357	Computer and office equipment	469	363	314
366	Communications equipment	296	269	255
367	Electronic components	610	610	700
737	Computer and data processing services	588	1,208	2,509

SIC = Standard Industrial Classification

NOTE: Data are projected based on a moderate growth scenario.

SOURCE: U.S. Bureau of Labor Statistics, *Monthly Labor Review* (November 1997).

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in terms of employment. Employment in two of the three IT-producing industries has been declining rather steadily since the early 1980s. Thus, trends in one sector mask patterns in another, much the way that the expansionary effects of IT could mask displacement effects within specific industries or occupations (and vice versa). For a discussion of trends in IT occupations see chapter 3, "Science and Engineering Workforce."

Skill Impacts and Wages

Assumptions about the information society and post-industrial economy suggest that the development of IT should increase the demand for workers who manipulate and analyze information relative to the demand for non-knowledge workers or those who simply enter and collate data. Yet there is a persistent popular fear of the deskilling effects of IT, a fear that automation will reduce the demands on an individual's conceptual talents and facility with machinery, equipment, and tools. Individual case studies of specific industries, occupations, and information technologies clearly illustrate that deskilling and skill upgrading take place simultaneously (for reviews, see Attewell and Rule 1994, and Cyert and Mowery 1987). On balance, however, several studies—using different data sets and methodologies—suggest that no overall lessening of skills is occurring in the workforce, and that upgrading may be widespread.

For example, Castells (1996) finds that employment in managerial, professional, and technical classes has been expanding at a rate faster than in non- and semi-skilled occupations. After an extensive review of trends in occupational categories, he concludes that:

> The widespread argument concerning the increasing polarization of the occupational structure of the information society does not seem to fit with this data set…I am objecting to the popular image of the information economy as providing an increasing number of low-level service jobs at a disproportionately higher rate than the rate of increase in share of the professional/technical component of the labor force (p. 219).

Howell and Wolff (1993) conclude much the same. Using detailed data on the cognitive and motor skills required for specific occupations from 1959 to 1990, they found that skill restructuring (principally upgrading) in the labor force began in the 1970s and continued in the 1980s in patterns that "are broadly consistent with what one might expect from the rapid expansion of new [information] technology" (p.12). They also found that the demand for the most cognitively skilled information occupations grew more rapidly than for other occupations during some periods. Analyzing data from the Annual Survey of Manufacturers, Berman, Bound, and Griliches (1994) document a significant skill upgrading throughout the manufacturing sector over the 1980s; they attribute the trend in part to computerization of the workplace. Their findings indicate a distinct shift in the demand for labor from less skilled to more highly (cognitively) skilled labor in the United States, a shift that has been linked theoretically and empirically to the diffusion of IT.

Autor, Katz, and Krueger (1997) similarly find evidence that computerization of the workplace may explain from 30 to 50 percent of the additional growth in demand for labor from 1970 to 1995, compared to growth from 1940 to 1970. They find that the increase in the rate of growth for skilled labor since 1970 is driven by rapid skill upgrading in industries that are the most computer-intensive (e.g., those that have the highest levels of computer investment per worker and the largest growth in the proportion of employees who use computers, and those in which computers account for a larger share of total investment). This study finds that those industries that experienced the largest growth in computer use also tended to shift their employee mix from administrative and support workers toward managers and professionals (a finding consistent with Castells 1996). Nonetheless, more systematic insight into which jobs are upgraded (or deskilled), and what happens to individuals whose jobs are deskilled, can provide a better sense of the organizational dynamics surrounding IT and their ultimate employment impacts.

Assumptions about the IT-skill upgrading relationship extend one more step, and also associate wage gaps with computerization in the workplace. Higher wages are attributed to the higher demand for computer-skilled labor, and lower wages are thought to reflect the absence of computer skills (see Bresnahan 1997 for a discussion of this literature). Autor, Katz, and Krueger (1997) support this thesis; as do Berman, Bound, and Griliches (1994).

However, Howell (1997) refutes the argument that skill mismatch is responsible for wage stagnation among less skilled workers by identifying a crucial anomaly in labor market behavior: employment in *low-skill* occupations is declining relative to more highly skilled jobs, but the proportion of *low-wage* workers is actually increasing. Bresnahan (1997) also provides an important critique of the research and empirical evidence on the impact of IT on the demand for skilled labor and wage gaps. He reviews alternative research that indicates that the actual use of IT (particularly PCs) on the job is inconsistent with assumptions about job enrichment.

and concludes that "there is little complementarity between highly skilled workers and PC use, certainly not enough to affect skill demand."

IT and the Worker

While IT may affect the individual worker in any number of ways, two particular effects are worth attention because of their negative physical and psychological aspects: the health hazards associated with the use of IT, and the emotional and behavioral consequences of workplace surveillance and monitoring.

IT is particularly associated with repetitive motion injury, even though a variety of other negative health effects are common, including eyestrain and a complex of musculoskeletal disorders (Huff and Finholt 1994). IT-based repetitive motions include barcode scanning, data entry and keying, and keyboard typing, all of which can lead to carpal tunnel syndrome and tendonitis—sometimes to the point of permanent disability. Data from the Bureau of Labor Statistics (BLS) indicate that the incidence rate of repeated trauma disorder rose from 6.4 per 10,000 FTE (full-time equivalents) in 1986 to 41.1 per 10,000 in 1994.[9] Although the manufacturing sector still accounts for the vast majority of these repetitive motion injuries, the number of repeated trauma disorders increased more than fivefold in the service sector between 1988 and 1992. Grocery stores, newspaper publishing, hospitals, and casualty insurance industries now rank among the 20 sectors with the highest incidence of the disorder, and BLS indicates several other service industries are "poised to enter the list," including airline scheduling, department stores, and mail order retailers (U.S. BLS 1994). The intensive use of IT is clearly an occupational hazard for individuals prone to repetitive motion disorder, but some researchers have found that a number of social and organizational factors can influence both the incidence of IT-related repetitive motion trauma and its severity (Kiesler and Finholt 1994, and Rowe 1994).

Workplace surveillance and monitoring also raise issues concerning workers' psychological health. The U.S. Office of Technology Assessment defined electronic workplace monitoring as "the computerized collection, storage, analysis, and reporting of information about employees' productive activities" (1987, p. 27); and it includes such measures as keystrokes typed per minute, length of time on a phone call, and length of time away from a computer terminal. Workplace monitoring is estimated to have doubled from 20 percent of all office workers in the early 1980s to 40 percent in the early 1990s, and spending on monitoring software is believed to exceed $1 billion (Aiello 1993).

The effect of workplace monitoring on the individual's well-being and work performance is unclear. One study (Grant, Higgins, and Irving 1994) found that monitored customer service employees believed that good work performance was quantity based, while nonmonitored employees focused on the quality of service and teamwork. Another analyst observed workers disconnecting phone calls if it appeared the caller would exceed the 22-second maximum time allotted by the firm to each call (Aiello 1993).

Overall, studies show that workplace monitoring may both increase and decrease productivity, and may or may not lead to greater stress, anxiety, isolation, and diminished work motivation. Actual outcomes depend on a variety of moderating factors in the workplace, including worksite, supervisor style, type and frequency of feedback, and the individual's sense of control over the monitoring itself.[10] Indeed, one study (on the impacts of IT on quality of worklife) concluded that although IT could intensify work pressures, it also enhances workers' sense of worth, accomplishment, and autonomy (Danziger and Kraemer 1986). Van Alstyne (1997) nonetheless regards surveillance and monitoring with suspicion, and concludes that there is good reason to expect that "those suffering reduced autonomy due to IT will seek ways to subvert the system, for example, through sabotage, disuse, delay, use of alternative procedures, supplying inaccurate data, or sticking to the letter but disregarding the intent of the system" (p. 40).

IT and the Productivity Paradox

One of the most debated issues about the impact of IT on the economy is that of the "productivity paradox"—the inability to find a statistical association between IT investments and productivity in the private sector. Despite compelling reasoning and evidence about the highly positive effects of IT on competitiveness and cost reduction,[11] traditional econometric analyses fail to find any productivity benefits for IT, and some studies identify negative productivity impacts for IT investments. The meaning of these findings is subject to considerable debate, with most experts advising caution in interpretation of the data. Problems with measurement and organizational learning lags are two explanations commonly offered to make sense of the counterintuitive empirical findings. However, the most current research on the IT productivity paradox suggests that it may have "disappeared" in the early 1990s; some analysts argue that the paradox is primarily the result of overly optimistic expectations about IT's economic effects.

The Empirical Studies

The IT productivity paradox was revealed by over 20 econometric analyses conducted and published between 1980 and 1990 (for detailed reviews, see Brynjolfsson and Yang 1996, and NRC 1994a). Regardless of the level of analysis chosen—the macroeconomy or specific industries and sectors—these studies demonstrated that there was no statistically significant, or even measurable, association between investments in IT and productivity.

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[9] These data are from U.S. BLS's Survey of Occupational Injuries and Illnesses and may be accessed from the Occupational Health and Safety Agency Web site <<http://www.osha-slc.gov/ergo/chart3.html>>.

[10] For a good overview of these issues and findings, see Aiello (1993).

[11] See Bender (1986); Benjamin et al. (1984); Harris and Katz (1991); Malone, Yates, and Benjamin (1987); Porter and Millar (1985); Bradley, Hausman, and Nolan (1993); NRC (1994a); and Byrne (1996).

The findings were troublesome not only because they contradicted strong expectations about positive effects, but also because productivity impacts apparently failed to materialize anywhere (not in services or manufacturing), by any measure (a variety of data sets and methods were used), or at any time (the studies collectively covered the late 1960s to the late 1980s). Findings of positive effects are reported in the literature, but this research represents one-time-only case studies of a single industry or small set of firms. The preponderance of the IT productivity research—which incorporates large and relatively comprehensive data sets at the firm, industry, and macro levels—consistently fails to demonstrate a significant positive impact by IT on productivity, regardless of sector or industry. Indeed, one widely cited study finds a negative correlation between investments in IT and multifactor productivity. Furthermore, this study identifies yet another anomaly: industries that are IT-intensive are more profitable than others; but within industries, such intensity is negatively associated with profitability (Morrison and Berndt 1990, and Berndt and Morrison 1995).

Two recent avenues of empirical analysis are, however, notable. Oliner and Sichel (1994) and Sichel (1997) report a small but positive association between IT and productivity using a growth accounting approach. Brynjolfsson and Hitt (1995 and 1996) find large and significant contributions by IT to productivity using a new firm-level database. Both sets of findings are highly suggestive about the nature of the IT productivity paradox. Sichel (1997) argues that it is primarily our expectations that are out of line with the long-term historical trends regarding both IT diffusion and the overall level of IT capital in the economy. Brynjolfsson and Hitt note that a full 50 percent of the variation in IT's contribution to marginal product can be accounted for by firm-level variables. This suggests that aggregate data are not likely to detect patterns in IT impacts, and that the effective use of IT is highly contingent upon the context of its use at the organizational level.

To elaborate, Oliner and Sichel find small but real contributions of computers to the economy. From 1970 to 1992, computer hardware contributed 0.15 percentage points to the total U.S. output growth rate of 2.8 percent. When software and computer-related labor are included, this contribution doubles to 0.31 percentage points for the period 1987 to 1993 (or 11 percent of total growth).[12] Other capital and labor inputs, as well as multifactor productivity gains, account for about 90 percent of the growth in U.S. output during this period.[13] The authors explain the small contribution of computers by observing that computing-related inputs are a very small portion of total capital and labor, and have only recently grown large enough to have a measurable impact. They conclude that "computing equipment can be productive at the firm level and yet make little contribution to aggregate growth, precisely because computers remain a relatively minor factor of production" (Oliner and Sichel, p. 286). Sichel (1997) expands on this argument by reflecting on trends in the diffusion of a variety of information technologies. He concludes that computing technologies are part of a 150-year trend toward greater information intensity in the United States, and that we should not expect the effects of computers to be large and sudden, but modest and part of a historical continuum.

Brynjolfsson and Hitt (1996) analyzed the impact of IT on marginal output using a new firm-level database and found large contributions of IT to marginal product for the firms in their study. Every additional dollar of computer capital stock was associated with an increase in marginal output of 81 cents, and every additional dollar spent on IT-related labor was associated with an increase in marginal output of $2.62. Their earlier work also demonstrates that firm-level factors account for half of the variability in IT's marginal product contributions (Brynjolfsson and Hitt 1995). In contrast, previous studies indicate that increases in IT are not associated with increases in marginal output; Morrison and Berndt (1990) found a negative relationship between IT spending and marginal output.

Several factors may explain the dramatically different findings of Brynjolfsson and Hitt relative to the earlier productivity studies. The later time period of their study (1987-91); the use of a larger data set; more detailed, firm-level[14] data; and the inclusion of IT-related labor (note that IT capital expenses are typically a small fraction of a firm's total IT-related costs) are all reasons why their findings are more positive than those resulting from earlier research. Using similar data and methods, other analysts have also found significant positive rates of return at the firm level, including Lichtenberg (1995) and Link and Scott (1998).

The studies by Oliner and Sichel, and Bryjolfsson and Hitt highlight the complexity of research into the effects of IT on productivity. Both sets of findings suggest that IT does have measurable payoffs for economic productivity, but the orders of magnitude are quite different. Macroeconomic impacts may be quite modest at best (as measured by Oliner and Sichel), whereas firm-level benefits may be more substantial (as measured by Brynjolfsson and Hitt). While they do not indicate that the productivity paradox has been resolved, these findings do suggest that the relationship between IT and productivity may be changing. Explanations for the paradox and the lagged benefits of IT therefore require further exploration.

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[12] Note that Jorgenson and Stiroh (1995), who also use a growth accounting approach, find an appreciably higher level of contribution by computing hardware to macroeconomic output. These authors estimate that computer hardware contributed 0.38 percentage points to the 2.49 percent growth rate from 1985 to 1992—more than double the 0.15 estimate provided by Oliner and Sichel. Differences are due in large part to the different time periods of the studies and to differing assumptions about depreciation rates. As with other economic analyses, assumptions can have a substantial impact on empirical estimates.

[13] Sichel (1997) asserts that there is no additional contribution of IT hidden in the multifactor productivity (MFP) estimate. MFP is a residual element that reflects technical and organizational changes that improve the efficiency of converting inputs into outputs, hence IT could contribute to gains that are captured by MFP. However, given the nature of growth accounting techniques, IT inputs would have to have a "supernormal" rate of return, and Sichel argues that there is no compelling evidence for such an assumption.

[14] Findings are based on a data set of 367 firms generating $1.8 trillion in aggregate sales in 1991.

Explanations for the Paradox

There are a number of interpretations of the productivity paradox, most falling into one of three categories:

- There is no paradox—IT does have positive effects on business and economic performance, but we are not able to measure these effects easily.
- The paradox is real but temporary—our social and organizational ability to adapt to new technology lags the pace at which the technology is introduced.
- The paradox is real and not temporary—the implication of which is that IT has no beneficial consequence for the economy, and hence reflects substantial opportunity costs (that is, money spent on IT is better spent elsewhere).

This third interpretation is not explored in this chapter, since the weight of evidence suggests that there *are* meaningful impacts of IT, challenging measurement problems, and very real social lags.

Excluding disagreements about the quality of various data used in the IT productivity studies (which has implications for sources of error in the findings), there are still a number of core measurement issues.[15] The first is, what constitutes IT? Is it capital investments only, or does it include labor, which represents the bulk of IT operating costs? Do IT capital investments include more than computers, and if so, what? The choices of what to count as an IT equipment expense include computing hardware and software, communications equipment, and a variety of office machines (such as photocopiers and some instruments). At present, there is little consistency among studies, and sources of IT investment data vary from aggregate government data to private survey-based firm data. One fundamental measurement issue is simply standardizing the definition of IT itself (labor, capital, and types of capital): standardized definitions can facilitate data collection, comparability across data sets, and cumulation of findings.

A second key measurement issue is how to assign dollar values to IT as a factor input. IT can be measured as a flow (annual expenses or purchases) or as a stock (the cumulation of equipment over time). In both instances, price deflators are required to compare stocks or flows over time by converting them to "real" dollars. IT equipment is especially problematic for establishing reliable deflators. For example, not only has the sales price of computing equipment been falling rapidly, but because quality has increased exponentially, existing computing stock becomes obsolete very quickly. The pace of technological change in information technologies greatly complicates analysts' abilities to construct quality-adjusted price deflators[16] and appropriate depreciation rates; distortions in time-series data can significantly affect research outcomes by over- or undervaluing expenses and stocks in different periods.

A third measurement concern relates to output—specifically, how to measure the output of information processing. IT is used extensively for "activities" that do not result in tangible market outputs (e.g., accounting, scheduling, reporting).[17] Consequently, it is difficult to assign a dollar value to the output of IT—a measurement that is crucial to accurate productivity analysis. This measurement challenge is exacerbated in the service sector, where output measures must also capture qualitative differences in services (Mark 1982 and Noyelle 1990); the problem is sufficiently severe that BLS does not report labor productivity for the software industry, a core IT sector (Goodman 1996). The potential for mismeasurement of services and information processing outputs, as well as IT as a factor input, is so troublesome that mismeasurement is usually cited as the primary explanation for the productivity paradox.

A fourth measurement issue deserves attention and has less to do with mismeasurement of a specific indicator (such as factor inputs and product outputs) than of measuring the wrong indicator to begin with. Studies of the applications and use of IT repeatedly demonstrate that IT benefits do not show up as classical efficiency gains, but as cost savings, improved inventory management, and qualitative improvements in customer service. These improvements reflect such dimensions as enhanced timeliness, performance, functionality, flexibility, accuracy, precision, customization, cycle times, variety, and responsiveness regardless of whether the output is a product or service or the consumer is an original equipment manufacturer, a distributor, or an end user (NRC 1994a; Byrne 1996; and Bradley, Hausman, and Nolan 1993). These qualitative dimensions are much more likely to show up as downstream benefits to the consumer (Bresnahan 1986) or as greater competitiveness for a firm—an outcome known as a "distributional effect" (Banker and Kauffman 1988, Baily and Chakrabarti 1988, Brynjolfsson 1993, and Porter and Millar 1985). In addition, Weill (1992) has found that the type of information processing (transaction) matters. In a study of valve manufacturers, data processing could be associated with productivity gains, but general business systems (like sales and marketing support) could not.

Institutional Lags

Another compelling explanation of the productivity paradox argues that it is a real but temporary phenomenon. Sociologists and economic historians have long argued (very cogently) that society's ability to fully exploit a new technology lags—often by decades—the introduction of the technology itself (Ogburn 1964 and Perez 1983). Similarly, in organizational change scholarship, analyzing institutional resistance to change (technological or otherwise) is the coin of the disciplinary realm. In theory and in practice then, as humans and their institutions become more accustomed to IT, productivity and other aspects of performance should improve.

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[15] The measurement problems are substantial and are discussed in detail elsewhere (Bryjolfsson 1993, Baily and Chakrabarti 1988, Griliches 1997, NRC 1994a, and Oliner and Sichel 1994).

[16] Note that the issues surrounding the measurement of services and their impacts are comparable to the methodological problems of measuring services and their impacts. Outputs are often intangible, quality is difficult to account for, and constructing R&D-specific price deflators is a complicated task. For more on R&D measurement issues, see NSB (1996), chapter 8.

[17] "Activities" are defined as repetitive and structured sets of work tasks; see NRC (1994a).

There is a good deal of evidence to support this argument. Important technological analogies for IT are electric generators and the electric power infrastructure. David (1989) found that it took nearly 20 years for the electric generator—an invention comparable to IT in scope and consequence—to have a measurable effect on industrial productivity; Friedlander (1997) found that historically it has been difficult to measure the benefits of most infrastructure technologies. With respect to IT specifically, firm-level performance can vary considerably, and the effective use of IT is apparently contingent upon a number of moderating variables at the organizational level—including strategy, leadership, attitudes, organizational structure, appropriate task and process reengineering, individual and organizational learning, and managerial style and decisionmaking (Cron and Sobol 1983; Curley and Pyburn 1982; Graham 1976; Thurow 1987; Landauer 1995; Tapscott 1996; Danziger and Kraemer 1986; Khosrowpour 1994; Banker, Kauffman, and Mahmood 1993; and Allen and Morton 1994). Other analysts argue that information technologies themselves are the cause of low productivity, since they are not necessarily user-friendly or well-designed. In this respect, evidence suggests that technological adaptation to social need has a lagged effect as well (Eason 1988, Landauer 1995, and Forester 1989).

The productivity paradox may thus be partially explained, but it does not dispel the observation that even as IT is radically changing the nature of some business activity, that activity does not necessarily get translated into greater efficiency or economic welfare. The banking industry is a good case study of the complexity of the paradox, and also of the possibility that the paradox may have "vanished" in the early 1990s for some sectors.

IT and the Banking Industry

The banking industry is one of the oldest users of information technologies—in the early 1950s, Bank of America was the first commercial user of mainframe technology (Morisi 1996). Yet the banking industry reflects most of the empirical dilemmas associated with measuring the impacts of IT: heavy investments in IT; slow (or no) visible improvements in productivity until relatively recently; and impacts that reflect quality improvements, rapid product diversification, and substantial growth in volume of commercial transactions.

IT has clearly changed both the structure and service quality of banking, and appears finally to have a positive impact on cost reduction. But it has taken decades to achieve these results, and traditional productivity analyses still do not detect positive associations between IT investments and productivity in the commercial banking sector.

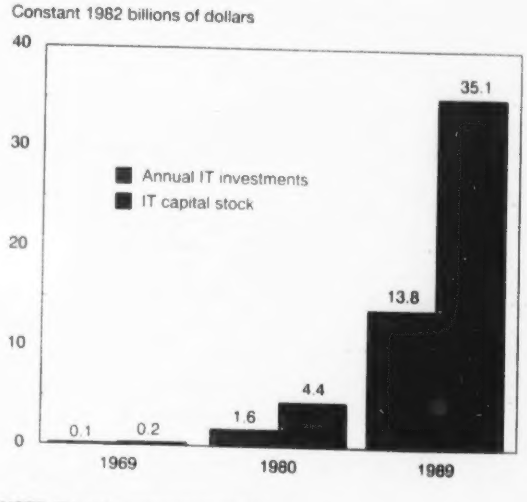
Banking industry investments in IT increased substantially from the late 1960s to the late 1980s. (See figure 8-11.) Annual investments in IT (in constant 1982 dollars) grew from $0.1 billion in 1969 to $1.6 billion in 1980 to $13.8 billion in 1989. By 1989, the banking industry was annually investing more funds in IT than were all of the other major service industries except telecommunications. The banking industry invested more in IT relative to its gross product output than the insurance, health care, air transport, telecommunications, wholesale trade, and retail trade industries. (See text table 8-4.)

IT uses are diverse in the banking sector. Initial applications included accounts management and check processing via magnetic ink character recognition. Automated clearinghouses, which enabled electronic funds transfer (EFT), were introduced in the early 1970s and ATMs in the late 1970s. EFT, ATM, and telephone transaction capabilities have replaced a wide variety of paper and in-person transactions in banking, including account deposit and withdrawals, accounts management, credit applications and approvals, cash dispensing, funds transfers, point-of-sale transactions, credit card payments, and consolidation of banking operations.

Impacts on Productivity

Reviews of the traditional econometric productivity literature indicate that IT investments by the banking industry do not systematically result in measurable, positive productivity

Figure 8-11.
IT investments by the banking industry



NOTE: IT is information technologies.

SOURCE: National Research Council, *Information Technology in the Service Society* (Washington, DC: National Academy Press, 1994).

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Text table 8-4.
Investments in information technologies by selected service industries: 1989

Industry	Investments in constant 1982 dollars (in billions)	Investments as a percentage of industry gross product output
Banking	13.8	19
Telecommunications	13.8	14
Wholesale trade	11.6	4
Retail trade	10.6	3
Insurance	6.2	17
Health care	3.6	2
Air transport	3.0	9

SOURCE: National Research Council, *Information Technology in the Service Society* (Washington, DC: National Academy Press, 1994).

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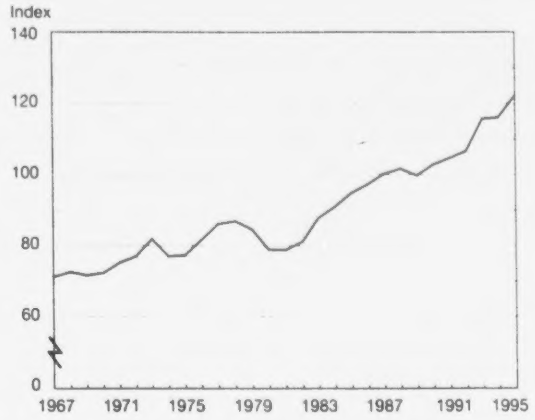
impacts. Major cross-sector studies (see Brynjolfsson and Yang 1996 for reviews) do not detect positive productivity returns for IT in the banking industry, and Franke's (1989) study of the financial sector (insurance and banking combined) suggests that IT is associated with negative productivity impacts. However, Brand and Duke (1982) do find productivity growth of 1.3 percent per year attributable to computers. Using qualitative evidence and interviews with chief executive officers, the National Research Council attributed the lack of productivity impact to a variety of factors. One is the ever present measurement issue: measures of output in the banking industry are extrapolated from employment data by the U.S. Bureau of Economic Analysis and estimated from indices of financial transactions (loans, deposits, and so forth) by BLS. Neither procedure fully accounts for the volume of banking transactions or wider variety of financial services; the inherent difficulty of measuring commercial banking output seriously qualifies productivity analysis using aggregate data sets.

Note, however, that labor productivity has been steadily improving in the banking industry. (See figure 8-12.) Morisi reports that "during the 1973-93 period, commercial banks had the highest long-term growth in productivity than any of the measured finance and service industries" (1996, p. 30). The difficulty is in empirically linking these improvements to IT.

A second reason for the apparent lack of IT-led productivity growth in this industry relates to problems with early generations of information technologies and organizational adaptation. The National Research Council study reported that:

> early applications of IT proved to be costly and cumbersome. Software and equipment had to be updated and replaced frequently…IT systems required large amounts of tailoring, training, upgrading, and updating. Cost control, management skills, and productivity tracking systems lagged behind the new technologies in a rapidly changing competitive marketplace…The result was that tangible paybacks from IT investments were delayed (NRC 1994a, pp. 80-81).

Figure 8-12.
Commercial banks output per employee
(Index: 1987 = 100)



See appendix table 8-10. *Science & Engineering Indicators – 1998*

Other Business Impacts of IT

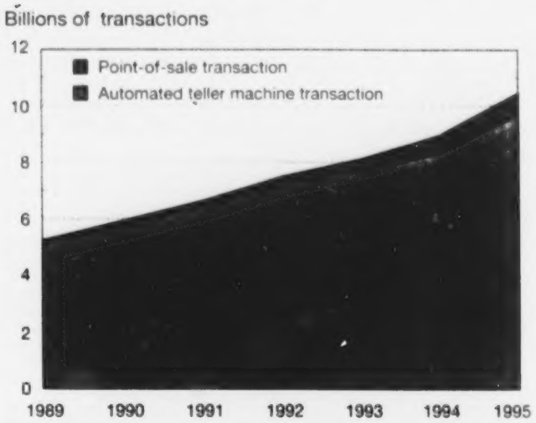
The significance of IT emerges in areas of business impact other than conventionally measured productivity gains. Three types of effects are worth particular note: the expansion of banking products and services, time and cost savings, and competitive positioning.

Banking products and services have proliferated with the use of EFT, ATM, telephone transactions, and automated credit and loan procedures. Banks thus process billions of transactions a year—everything from clearing individual checks, to ATM cash dispersal, to account inquiries, to loan approvals—a volume of interactions that would simply not be possible without automation. For example, the Clearinghouse for Interbank Payment Systems was processing nearly $2 trillion worth of transactions *per day* by the late 1980s, and Visa's capacity for authorizing credit card transactions increased from 30,000 per day in 1978 to 1.4 million per day in 1991 (NRC 1994a, pp. 83-84). Bresnahan (1986) estimates that the benefits to consumers of the use of mainframe computers for financial services was five times greater than the investments in the computers themselves.

The qualitative improvement in customer convenience, ease, and scope of access to financial resources is reflected in the overall growth of electronic transactions. Figure 8-13 illustrates the expansion of electronic (ATM and point-of-sale) transactions in the United States: the number of electronic cash transactions and payments for goods and services was more than 10 billion in 1995, compared to just over 5 billion in 1989.

Time and cost savings for the industry are also notable. For example, Mellon Bank reduced the average processing time of customer complaints by 20 days when it installed an integrated document system; Visa reduced its processing time for electronic credit card authorizations from 5 minutes in

Figure 8-13.
U.S. electronic funds transfer volume



SOURCE: U.S. Bureau of the Census, *Statistical Abstract of the United States 1996*, table 795 (Washington, DC: U.S. Government Printing Office, 1996). Data are proprietary to Faulkner & Gray (Chicago).

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1973 to 1.1 seconds in 1991; and the Bank of Boston reduced its staff requirements by 17 percent and increased its transaction volume by 80 percent when IT allowed the bank to consolidate its mainframe operations (NRC 1994a, pp. 83-84). The American Bankers Association estimates that ATM transactions cost 27 cents compared to $1.07 for a human teller, and telephone transactions cost about $0.35 compared to $1.82 for a phone call processed by bank personnel (Morisi 1996). In a study of 759 banks, Alpar and Kim (1991) found that a 10 percent increase in IT expenses led to a 1.9 percent decrease in total bank costs.

Although the productivity measures do not find a link between banking industry output and IT investments, it is important to note that while the volume of financial transactions has been increasing at a dramatic rate, employment in the sector has been falling. By 1996, employment in the commercial banking industry was 100,000 employees below its historic peak in 1990. During the same period, the number of ATM transactions doubled to more than 10.5 billion.

IT is of value to the banking industry not only for time savings, cost reductions, and customer services, but for the ability to give individual banks a competitive advantage or the ability to maintain a competitive position. Deregulation of the industry in 1980 led to intense rivalry among institutions, and expanding automated services was one way of attracting depositors and customers. Thus Banker and Kauffman's (1988) study of 508 branch banks found that ATMs were essential to maintaining market share and customer base—not necessarily to reducing costs.

Implications for IT Metrics

The banking industry illustrates many of the issues involved with establishing useful metrics for analyzing the economic impacts of IT. Not only are there problems with measuring the output of this industry in a meaningful way (productivity estimates require output estimates), but there is the issue of what to measure in the first place. IT clearly provides "value added" in a range of consumer and producer activities that are not captured by productivity analysis, such as convenience, scope of services, access, time savings, transaction volume, and transaction cost reductions. The challenge is to select one or two representative measures of impact and track their performance over time.

The industry may have experienced a long learning curve in terms of adaptation to new information technologies. Insight into how banks reengineered their organizations, management strategies, and work tasks could inform IT strategies in other industries and shorten the lag between the time a technology is introduced and the time it begins to measurably enhance business performance.

IT, Education, and Knowledge Creation

Information technologies are likely to have a substantial impact on the entire spectrum of education by affecting how we learn, what we know, and where we obtain knowledge and information. IT influences everything from the creation of scientifically derived knowledge (see "IT, Research, and Knowledge Creation") to how children learn in schools; lifelong learning by adults; and the storage of a society's cumulative knowledge, history, and culture. Because IT networks create remote sources of instruction and geographically distributed information resources, learning, knowledge generation, and information retrieval are no longer confined to the traditional spaces of laboratories, schools, libraries, and museums.

As a consequence, new education activities such as distance learning are clearly on the rise.[18] (See chapter 2, "Distance Learning and Its Impact on S&E Education.") In 1984, fewer than 10 states had distance learning facilities, but by 1993 all 50 states did. In the same year, the 20 largest providers of satellite-based instruction purchased 75,000 hours of satellite transponder time; assuming that coursework would be broadcast during a 40-hour week, these top 20 providers purchased the equivalent of 36 instructional years (Katz, Tate, and Weimer 1995).[19] Internet Distance Education Associates estimates that more than 100 U.S. colleges and universities offer courses over the Internet;[20] National Technical University, a satellite TV educational institution, has over 800 receiver sites (Katz, Tate, and Weimer 1995). Also new are digital

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[18] "Distance learning" refers to education that takes place via electronic means, such as satellite television or the Internet. There is no single organization responsible for certifying or monitoring distance education in the United States, so there are no uniform statistics or a centralized directory of distance learning providers.

[19] Note that there are more than 100 major providers of satellite-based instruction.

[20] Data available from <http://www.ivu.com>.

IT, Research, and Knowledge Creation

IT has fundamentally enhanced the conduct of scientific research, data modeling and analysis, and the creation of scientifically derived knowledge. The most pervasive change is the emergence of the "global laboratory"—Internet connections now allow scientists to control instrumentation from a distance, share research findings instantaneously with other scholars around the world, and develop international databases and collaborations. The research applications of networking are extensive (see NRC 1993 and 1994b); IT has gradually eroded the geographic constraints on the conduct of research and knowledge cumulation.

High-speed computing and advanced software applications have also enhanced the analysis of scientific data and drastically shortened the amount of time required to perform certain scientific tasks. For example, data visualization provides dynamic, three-dimensional modeling of complex systems data such as fluid dynamics, while imaging technology provides visual tracking of such minute cellular changes as embryo development. In biology, major advances in rapid gene sequencing and protein mapping are the direct result of highly advanced computational programs (*Science* 1996).

IT also provides knowledge we would not otherwise have—satellite-based technologies are particularly noteworthy. For example, the global positioning system allows geologists to measure precise movements in the earth's crust, thus identifying communities that are vulnerable to earthquakes and aiding in earthquake prediction (Herring 1996). Global climate change modeling similarly owes its advances to satellite-based data collection and transmission; in turn, more detailed knowledge of historical climate patterns has improved our understanding of some infectious diseases and epidemics (Colwell 1996).

Advancement in scientific knowledge is not limited to higher education. An innovative IT-based program includes precollege students from around the world in the research process. The Global Learning and Observations to Benefit the Environment (GLOBE) Program provides environmental science education to K-12 students in more than 3,500 schools and 45 countries. These students collect environmental data for use by the scientific community in research on the dynamics of the earth's global environment. Students report data on the Web, generate graphical displays and contour maps, and interact with international research scientists as well as other GLOBE students (Finarelli n.d.).

museums, which allow millions of individuals access to history and culture they would not otherwise have.[21] These include Fisk University's collection of 7 million African American artifacts; the Vatican's 600-year-old collection of over 1 million books and manuscripts (including the only known copies of many historically significant documents); and the Library of Congress's American Memory Collection of documents, films, photographs, and sound recordings (Memmott 1997). Libraries are undergoing comparably profound digital revolutions (see "IT and the Changing Nature of Libraries").

Because of the growing role of IT in learning and in expanding the scope of educational resources, many people are concerned about the accessibility of information technologies to the nation's schools and the effects of these technologies on students—particularly K-12 children. This section looks at the diffusion of IT in U.S. elementary and secondary schools as well as the effects of computer-based instruction on student achievement. Inequities in student (and household) access to IT are considerable; these are addressed in the final section of this chapter, "IT and the Citizen."

IT and Precollege Education

National pressures to increase the scope and use of information technologies in U.S. elementary and secondary schools are persistent (PCAST 1997, NIIAC 1995, The Children's Partnership 1996, and McKinsey and Company 1995). In most instances, the primary reason for greater emphasis on IT is adequate job training, although there is notable concern over avoiding a stratified society in which the "information haves" are divided from the "information have-nots." Greater use of IT at the precollege level is frequently understood as the training students need to be competent members of the information society and to enjoy an information-enhanced quality of life.

Assumptions about the educational, employment, and life-enhancing benefits of IT are not universal, however. *Silicon Snake Oil: Second Thoughts on the Information Highway* by Clifford Stoll (1995) represents one popularized critique of claims about the social payoff of IT (including educational benefits). Additionally, scholar Larry Cuban (1994) has repeatedly raised the question "should computers be used in classrooms?"; and journalist Todd Oppenheimer (1997) has explored the significant educational opportunity costs that may emerge with greater spending on IT. The fundamental dilemma of computer-based instruction and other IT-based educational technologies is that their cost effectiveness compared to other forms of instruction—for example, smaller class sizes, self-paced learning, peer teaching, small group learning, innovative curricula, and in-class tutors—has never been

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[21] This "digitizing of history"—particularly that of perishable or fragile photographs, artwork, documents, recordings, films, and artifacts—represents a socially invaluable preservation function and allows people to view items that could never be displayed publicly. Note that the Library of Congress Web site <<http://www.loc.gov>> had over 42 million hits in April 1997 alone (Memmott 1997).

IT and the Changing Nature of Libraries

Historically, the public library has played a central role as an information resource in American communities. Gallup polls indicate that the majority of American adults still regard the public library as a key center for educational support, independent learning, research, community information, and reference resources (NRC 1994b). Not surprisingly, the United States has the most extensive public library system in the world, and more than one-half of the adult population and three-quarters of adolescent children use public libraries.

With the advent of new information technologies, the nature of library information resources is changing. Electronic information services are increasingly common; and CD-ROM databases, remote database searching, and on-line catalogs are available in more than two-thirds of the U.S. public libraries that service communities of 100,000 or more individuals. Networks allow libraries to leverage their resources through interlibrary loans and have stimulated the development of the "digital library," a concept that reflects the digitization of library resources and collections. The ability to store and transmit mixed-media resources (see the text discussion of digitized museums) gives greater significance to nonprint information resources (such as sound recordings and visual images) and has stimulated librarians to expand and diversify their information management skills. Stewardship of library information has moved from a "just-in-case" model of on-site materials to a "just-in-time" model of resource access and sharing.

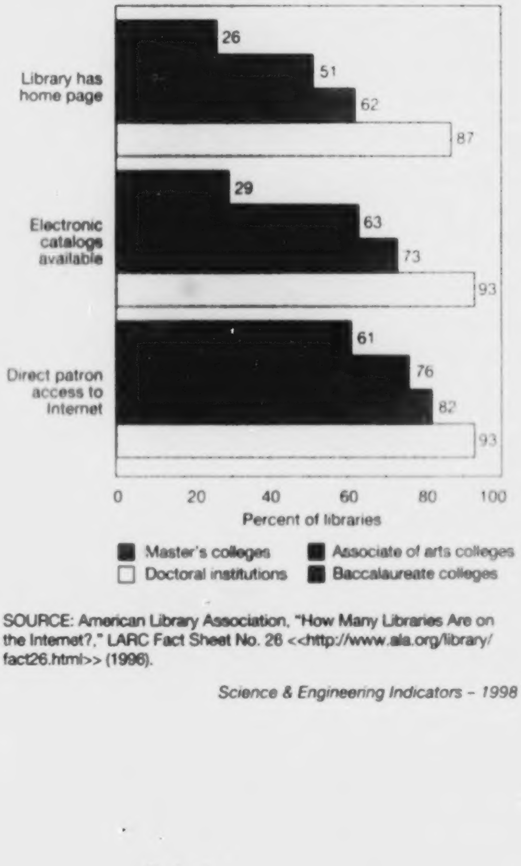
The Internet has significantly expanded the resource base of public libraries. Library-based access provides a number of advantages to Americans. First, it is an affordable, equitable, and ubiquitous point of access for most individuals. Second, locally developed databases and network linkages are highly responsive to the needs of the local community and can facilitate more effective network use. Third, the library can act as an electronic gateway to information for people who would not otherwise have access to the Internet.

Barriers to library connectivity exist, as evidenced by the relatively low level of library linkage to the Internet. Less than half of public libraries (45 percent) were connected to the Internet in 1996, a figure that masks considerable variation by community size: less than one-third of libraries in communities of less than 5,000 individuals had Internet access (31 percent), compared to the 82 percent of libraries serving metropolitan areas over 1 million people. For the roughly 500 libraries that serve metropolitan areas of 100,000 or more, 93 percent offer Internet access to the library staff, and one-half offer access directly to patrons (ALA 1996). As access fees decline, it is likely that more libraries will connect to the Internet: representatives of more than 70 percent of those libraries not now connected say they plan to do so within the next year (ALA 1996).

In contrast, academic libraries are highly "wired," but with variations by type of institution. Associates degree colleges lag other institutions of higher education on most dimensions of electronic access to resources, including direct patron access to the Internet, the availability of electronic catalogs, and the library's development of its own home page for students. (See figure 8-14.)

For more information on the substantial changes in library activities related to the use of IT, see NRC (1994b), Lyman (1996), and Lesk (1997).

Figure 8-14.
Academic library access to electronic resources: 1996



SOURCE: American Library Association, "How Many Libraries Are on the Internet?," LARC Fact Sheet No. 26 <<http://www.ala.org/library/fact26.html>> (1996).

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proven (Rosenberg 1997, Cuban 1994, and Kulik and Kulik 1991). Although real IT learning benefits have been measured and demonstrated, whether the magnitude of these benefits is sufficiently large to justify limiting other school curricula and programs is open to question.

The budget issues and educational opportunity costs associated with IT are not trivial. In a report to the U.S. Advisory Committee on the National Information Infrastructure, McKinsey and Company (1995) estimated that about 1.3 percent of the national school budget is spent on instructional technology. Heightening the level of IT in K-12 public schools would require raising this share to as much as 3.9 percent, depending on the degree of IT intensity desired.[22] This spending increase is for hardware only, and does not include IT operational expenses or the cost of teacher training, a significant factor in the effectiveness of computer-based instruction (U.S. OTA 1995, McKinsey and Company 1995, Ryan 1991, and PCAST 1997). Yet inflation and the expanding school-age population account for almost all growth in school budgets; the McKinsey report states that only 1.6 percent of the growth in per student expenditures is available for IT and other discretionary spending, including building repair and maintenance, school security, teacher salaries, and the operating costs of IT hardware. Because school districts are under increasing fiscal stress, expanding IT resources could mean cutting other important programs. Oppenheimer (1997) details sacrifices in art, music, physical education, vocational trade ("shop") classes, and textbook purchases that have been made for computers. The negative impacts of these sacrifices on learning and job skills are not usually considered in the growing emphasis on CBI. Also not considered is the potential decline of "collateral" and experiential learning that may occur as more instruction is shifted to the computer (Cuban 1994).

Our understanding of the learning impacts of CBI is primitive. The research reported below does find systematically positive learning benefits associated with computer use in schools, but the magnitude of the benefits is often modest and varies by level of education, characteristics of the learners, characteristics of the instruction and teachers, subject matter, and type of computer application. CBI is a broad category that captures computer-assisted instruction (typically drill-and-practice exercises or tutorial instruction), computer-managed instruction (the computer monitors student performance and progress and guides student use of instructional materials), and computer-enriched instruction (the computer functions as a problem-solving tool). Categories of software use are even more extensive and include generic information-handling tools, real-time data acquisition, simulations, multimedia, educational games, cognitive tools, intelligent tutors, construction environments, virtual communities, information access environments, information construction environments, and computer-aided instruction (Rubin 1996). Software (courseware) for inquiry-based learning[23]—the ultimate goal of most CBI advocates and the most cognitively demanding form of learning—is in short supply. This resource deficiency may be one cause of the limited measurable impacts of CBI on higher order thinking skills and learning (Kulik and Kulik 1991, PCAST 1997, and McKinsey and Company 1995).

Research data suggest that CBI appears to be most effective with rote learning at the elementary school level and in special education settings (that is, in remedial work, or with low achievers or those with learning disabilities). The impact of CBI on critical thinking and synthesis skills is much harder to demonstrate. Also unclear is how to maximize the effectiveness of CBI in the classroom: empirical studies often account for 40 or more contextual variables related to learning and instruction. Schofield (1995) sheds light on this contextual complexity of computers and learning in her detailed two-year case study of computer use at a typical urban high school. Her findings demonstrate how the social organization of the school and classrooms affect computer-related learning, behavior, attitudes, and outcomes. On balance, Schofield found that computers aggravated pre-existing differences between academically advanced and "regular" students, boys and girls, and college-bound and non-college-bound students.

Computer-based instruction clearly does not take place in a vacuum, but systematic understanding of the social and cognitive complexity of computer-based learning is limited. As the President's Committee of Advisors on Science and Technology, Panel on Educational Technology, concluded,

> Funding levels for educational research have been alarmingly low…In 1995, less than 0.1 percent of our nation's expenditures for elementary and secondary education were invested to determine which educational techniques actually work, and to find ways to improve them (PCAST 1997).

Diffusion of IT in K-12 Education

Over the past 20 years, computers and other information technologies have been diffused widely in the U.S. K-12 educational system. Ninety-eight percent of all schools have at least 1 microcomputer for instructional use, and about 80 percent have 15 or more (see figure 8-5 earlier in this chapter). One-half of a school's instructional computers are located in the classroom, 37 percent are located in computer labs, and approximately 13 percent are placed in other public access rooms such as a library or media center. This distribution has not changed since the mid-1980s.[24]

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[22] For example, ensuring adequate pupil-to-computer ratios and Internet connections to the school versus universal classroom deployment of full multimedia computers, Internet connections, and school networks. The McKinsey report details three alternative IT models and estimated costs.

[23] Inquiry-based learning represents active learning on the part of a student rather than the passive assimilation of information "taught" by an instructor. Inquiry-based learning reflects active construction of models for conceptual understanding, the ability to connect knowledge to the world outside of the classroom, self-reflection about one's own learning style, and a cultivated sense of curiosity. See Rubin (1996).

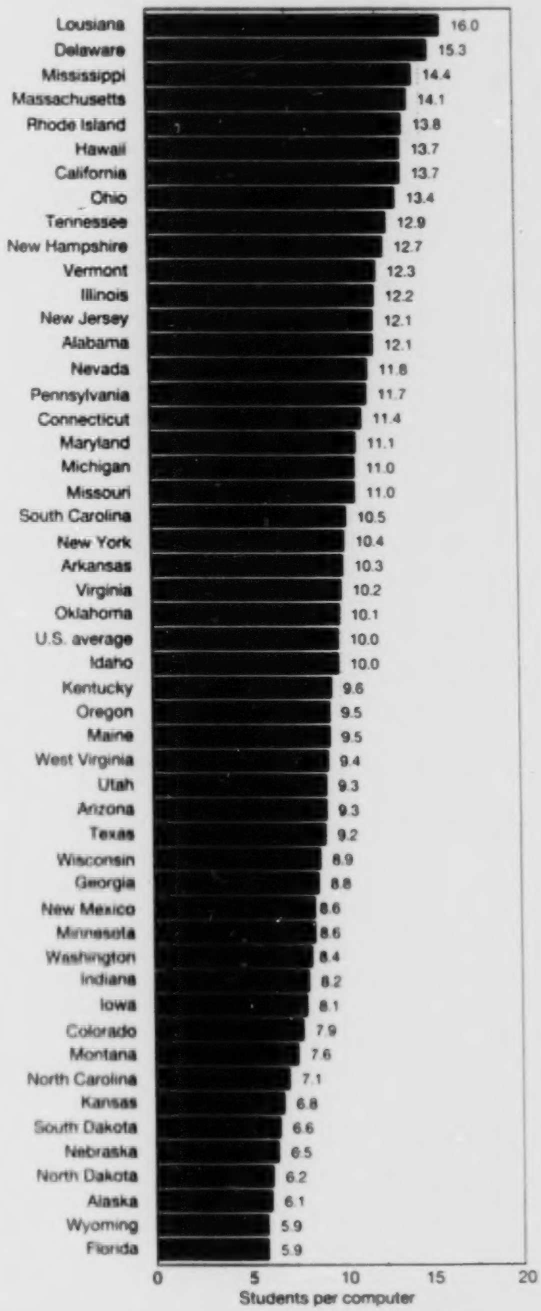
Estimates of the average number of computers per pupil in the early 1980s vary widely—from 42 to 125 students per computer; but data consistently indicate that the ratio now is approximately 10 or 11 students per computer (ETS 1997).[25] Disparities in student access are considerable, however. The differences in students per computer by state of residence range from about 6 pupils per computer in Florida to 16 in Louisiana. (See figure 8-15.)

Schools have also adopted other information technologies. For example, in 1996, 85 percent of schools had access to multimedia computers, 64 percent had Internet access, and 19 percent had satellite connections. (See figure 8-16.) Diffusion of these additional information technologies has been quite rapid. In 1992, only 8 percent of schools had an interactive videodisk, compared to 35 percent in 1995; 5 percent of schools had local area networks, compared to 38 percent in 1995; and only 1 percent had satellite dishes, compared to 19 percent in 1995. (See appendix table 8-7.)

School access to these technologies does not necessarily mean that they are used for instructional purposes, however. The National Center for Education Statistics reported that 65 percent of all public schools had Internet access in 1996, but only 14 percent of school rooms actually used for instruction were linked to the Internet (NCES 1997).[26] On a state-by-state basis, the number of schools with Internet access varies far more than the student-to-computer ratios. (See figure 8-17.)

A 1992 survey of elementary and high school principals indicates that the three most important reasons schools adopt computer technologies are to (1) give students the experience they will need with computers for the future, (2) keep the curriculum and teaching methods current, and (3) improve student achievement (Pelgrum, Janssen, and Plomp 1993). There are, however, notable differences in the ways in which computers are actually used: the higher the school grade, the more computers are used for computer training and the less they are used for teaching academic content. At the fifth grade level, 58 percent of CBI time relates to subject matter, and only 32 percent relates to computer skills such as word processing and spreadsheets. By 11th grade, more CBI time is spent on computer skills (51 percent) than academics (43 percent); instructional use for math and English drops from 35 to 14 percent.[27] (See text table 8-5.)

Figure 8-15.
Number of K-12 students per computer, by state: 1995-96



SOURCE: Educational Testing Service, *Computers and Classrooms: The Status of Technology in US Schools, Policy Information Report* (Princeton: Educational Testing Service, Policy Information Center, 1997).

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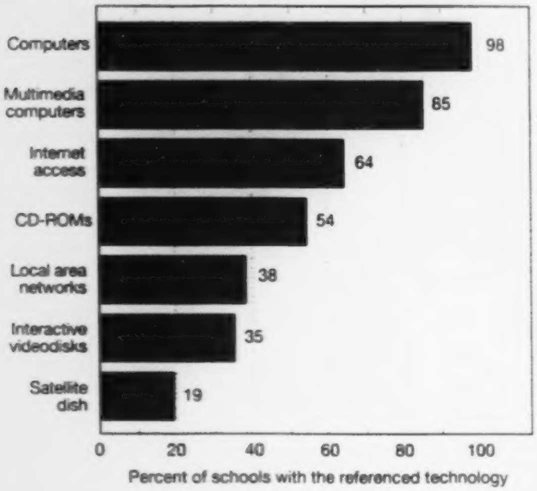
[24] See U.S. Bureau of the Census (1996), table 262; these data are based on the Computers in Education Study conducted by the International Association for the Evaluation of Educational Achievement (see IEA n.d.).

[25] See also U.S. Bureau of the Census (1996), table 261 (based on unpublished data from Market Data Retrieval), and table 262 (based on IEA n.d.).

[26] There were also significant differences in Internet access based on minority enrollment. See chapter 1, figure 1-17 and related discussion, and appendix table 1-25.

[27] The President's Committee of Advisors on Science and Technology has recommended that the primary focus of computer-based instruction be content-oriented rather than skills training. See PCAST (1997).

Figure 8-16.
Diffusion of IT in U.S. public schools: 1996



NOTE: IT is information technologies.

SOURCE: Educational Testing Service, *Computers and Classrooms: The Status of Technology in US Schools, Policy Information Report* (Princeton: Educational Testing Service, Policy Information Center, 1997).

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Text table 8-5.
Instructional use of computers in K-12 education: 1992
(Percentages)

Type of use	Total	Grade 5	Grade 8	Grade 11
Total student use	100	100	100	100
Academic subjects	51	58	44	43
Mathematics	15	18	12	7
English	13	17	10	7
Science	7	8	7	6
Social studies	7	9	6	3
Business education	4	3	3	10
Industrial arts	2	1	3	6
Fine arts	2	2	2	2
Foreign languages	1	–	1	2
Computer training	39	32	46	51
Word processing	14	12	16	17
Keyboarding	14	13	15	14
Programming	5	3	7	8
Spreadsheets	6	4	8	12
Recreational use	9	10	10	6
Other	1	1	1	–

SOURCE: U.S. Bureau of the Census, *Statistical Abstract of the United States 1996*, table 262 (Washington, DC: U.S. Goverment Printing Office, 1996); based on the Computers in Education Study conducted by the International Association for the Evaluation of Educational Achievement.

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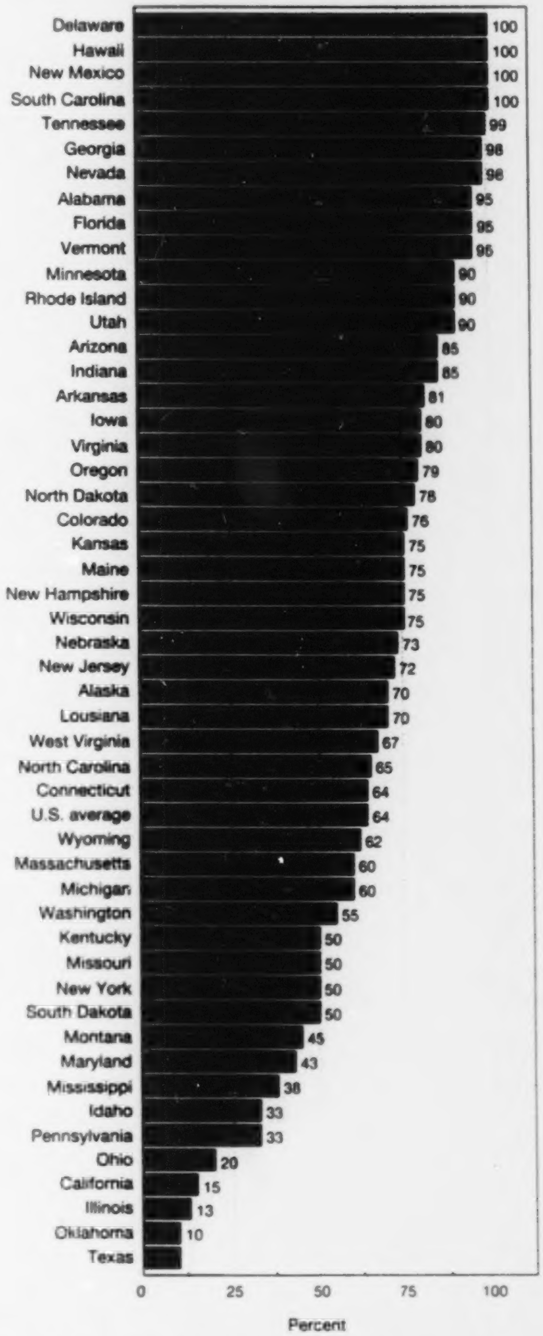
Figure 8-17.
Percentage of K-12 schools with Internet access, by state: 1996



SOURCE: Educational Testing Service, *Computers and Classrooms: The Status of Technology in US Schools, Policy Information Report* (Princeton: Educational Testing Service, Policy Information Center, 1997).

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Impacts of IT on K-12 Student Learning

A keyword search of ERIC, the primary bibliometric database used for educational research, yields thousands of citations related to computer-assisted instruction and student achievement. The signal characteristic of this research is its seeming lack of comparability: studies range from anecdotal reports to formal experimental designs, many of which control for different sets of variables and include different types of computer use in different subject areas. Moreover, interest in the effects of computers on young people is not limited to learning and achievement. Concerns about the emotional and psychological effects of prolonged exposure to computing environments have also been raised. (See "Children, Computers, and Cyberspace.")

One way of integrating disparate research is with "meta-analysis," a statistical technique used in the field of education and other disciplines.[28] Meta-analysis provides a way of standardizing the statistical results of quantitative research so that multiple studies can be compared in a reliable manner. About a dozen meta-analyses have been conducted on the effects of computer-based instruction, all of which find positive (though not necessarily large) learning effects. The magnitude of learning effects varies across a host of conditions, including type of instruction, subject matter, duration of the experimental treatment, and degree of teacher training. Detailed information on meta-analysis as an integrating methodology is presented here, as are two meta-analyses of the impacts of CBI on precollege learning. These studies illustrate the methodology of meta-analysis, the resulting metrics, and the interpretation of such metrics.

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[28] Detailed reviews of the meta-analytic technique may be found in Hittleman and Simon (1997); Kulik and Kulik (1991); Ryan (1991); McNeil and Nelson (1990); and Glass, McGaw, and Smith (1981).

Children, Computers, and Cyberspace

Education scholar Larry Cuban once remarked that "if the full influence, both positive and negative, of television watching on children continues to be debated three decades after its introduction, how can anyone assess the complexity of what happens to children using classroom computers?" (1994, p. 537).

The comparison to television is pertinent, since many of the concerns raised about children, computers, and the Internet are similar to those raised in the past for TV. Of particular concern is the psychological and emotional well-being of children. Cyberspace brings its own set of potential dangers to children, including cyberhate and cyberporn—forms of adult expression that children might not be able to handle.

The extent of the problem—the access by children to age-inappropriate materials on the Internet—is debated intensely. The ease with which children may access sexually explicit materials is disputed (see Gay 1996), but congressional testimony (U.S. Senate 1995) and case studies (Turkle 1995) reveal that young people can easily obtain graphic sexual photographs and engage in "netsex" on the Internet; one young teen also reported being electronically stalked by an adult who clearly knew she was a minor.

The primary legislative effort to protect children on the Internet was the Communications Decency Act of 1996, a law that made providing "indecent" material to minors over the Internet a crime. The act was declared unconstitutional by the Supreme Court in 1997 (*Reno v. American Civil Liberties Union*) for a variety of reasons, including the fact that indecent material has consistently been protected as a form of free speech in the United States. (The Supreme Court has historically made a distinction between indecent and obscene material; obscenity is not protected under the First Amendment.) Limiting children's access to inappropriate materials has now become a technological challenge, relying on such filtering software as Cyber Patrol™ and CYBERsitter™. Adult verification systems such as Adult Check™ also are becoming more common. Note that children's vulnerability is not limited to sexually explicit materials; parental concerns have also been raised with regard to Internet violence, hate speech, deceptive advertising, "false front" Web sites, and exploitation of children's privacy.

Concerns about core psychological processes—such as self-identity—have also been examined. Sherry Turkle, a behavioral scientist who studies the impact of early and prolonged use of computing environments on children, has uncovered patterns that suggest the computer culture is not benign. Computing and cyberspace may blur children's ability to separate the living from the inanimate, contribute to escapism and emotional detachment, stunt the development of a sense of personal security, and create a hyper-fluid sense of identity (Turkle 1984 and 1995).

While there may be psychological benefits associated with computer-mediated reality (including greater empathy for those of different cultures, sex, or ethnicity; heightened adaptability; and a more flexible outlook on life), the "darker side" of the technology is nonetheless unsettling. Turkle raises the possibility that extensive interaction with cyberspace (especially through multi-user domains) may create individuals incapable of dealing with the messiness of reality, the needs of community building, and the demands of personal commitments (Turkle 1995).

Meta-Analysis

Meta-analysis is a method for combining the statistical results of research studies that test the same general hypothesis and use the same statistical measures. Meta-analysis related to CBI focuses primarily on the impact of computer usage on student learning, although other educational outcomes may be studied (such as attitudes toward computers, attitudes toward school subjects, and amount of time needed for instruction).

As discussed here, meta-analysis yields a standardized metric called an "effect size." Effect size is a score that measures the difference in performance between experimental and control groups. For CBI, effect size is based on the performance of control and experimental groups on a common examination. As a metric, effect size is expressed as a proportion of standard deviation (a z-score) and has a percentile equivalent; it also controls for the influence of sample size.[29] The z-score reflects how much better (or worse) the experimental group performed on an exam relative to the mean of the control group. Examples of effect sizes and their interpretation are provided below in the discussion of specific meta-analytic research.

Meta-analysis is valuable for two key reasons. First, it allows researchers to cumulate and integrate the findings of multiple studies (particularly those that are small in size) into a single measure of outcome. Second, it estimates a specific magnitude for an independent variable's impact. Other methods that aggregate diverse studies, such as "tallies" and "box scores," indicate overall patterns and trends in research findings but do not estimate the degree of influence of one variable on another.

Meta-analysis has a number of potential weaknesses, however. First, biased or flawed studies, when cumulated, will generate biased or flawed meta-analysis. Second, for some types of meta-analysis, aggregative data can lead to "Simpson's Paradox"—an outcome in which the statistics indicate a relationship opposite to what is actually occurring. Simpson's Paradox is most likely to occur with the aggregation of categorical data, such as that of risk assessment (see Utts 1996). Third, the results of meta-analysis are point estimates; that is, they are single numeric values (z-scores) without reference to a confidence interval or some estimate of the precision of the estimates themselves. As a consequence, meta-analysis z-scores reflect a level of unmeasured uncertainty.

Meta-analysis therefore relies upon rigorous research designs to avoid potential pitfalls. Two factors affect the overall quality of a meta-analytic study (Hittleman and Simon 1997, and Utts 1996). One factor is the decision about what primary research to include in the synthesis. Ideally, only research that reflects experimental and quasi-experimental design should be used; target groups should contain large numbers (typically 20 or more units of observation); data on means, standard deviations, and sample sizes should be reported; and methodologically flawed studies should be eliminated from the analysis. In this way, only the most rigorous studies are included for synthesis. Second, because meta-analysis must account for a large number of other factors that can potentially affect the dependent variable, coding of these additional factors must be particularly precise and consistent. As a consequence, the meta-analysis research design must contain provisions for checking intra- and/or inter-coder reliability. The two studies reported below conform to the general requirements for proper meta-analysis and avoid the most common pitfalls associated with this type of research.

Meta-Analyses of Computer-Based Instruction

In general, traditional literature reviews and box-score tallies of computer-based instruction research indicate positive effects. CBI appears to result in some degree of observable achievement effect most of the time, but not always. Meta-analyses try to quantify precisely the magnitude of these effects; over a dozen meta-analyses of CBI covering precollege and postsecondary education have been conducted.[30] Three observations are worth noting here.

- ◆ In their review of 11 meta-analyses, Niemiec and Walberg (1987) find evidence that effect sizes for high school and college tend to be smaller than for elementary school and students with special learning needs.
- ◆ There is systematic evidence that CBI effect sizes are higher in the published literature than in unpublished documents such as dissertations, conference papers, technical reports, and professional presentations. Meta-analyses must consequently include nonpublished research findings to avoid overly positive estimates of the impact of CBI on student learning.[31] The two meta-analyses discussed in detail here (Kulik and Kulik 1991, and Ryan 1991) take care to include a variety of nonpublished literature in their syntheses.
- ◆ The meta-analyses conducted to date cover CBI only from the late 1960s to the mid- to late 1980s. Therefore, these studies do not reflect the substantial changes in computer hardware, educational software, teacher preparedness, and styles of computer-based teaching and learning that may have occurred in the 1990s.

Kulik and Kulik (1991) performed a meta-analysis on 254 studies conducted between 1966 and 1986. The CBI effectiveness studies included in the meta-analysis reflect (1) all levels of education—precollege and postsecondary, (2) controlled evaluations[32] in real classroom settings, not laboratories; and (3) research free from a number of methodological flaws specified by the authors. Even though the studies themselves reflect controlled research designs, they often capture different contextual factors. As a consequence, Kulik and Kulik coded a large set of "control" variables that might affect learning outcomes, such as the type of computer application, the instructor, and course content. (See text table 8-6.)

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[29] Studies with small sample size tend to have large statistical variance, while large studies have smaller variance. Meta-analysis controls for variance and provides greater weight to the results of large studies, which tend to be more statistically robust.

[30] Niemiec and Walberg (1987) identify 11 such studies; more recent meta-analyses include Kulik and Kulik (1991), Ryan (1991), and McNeil and Nelson (1990).

[31] This is not necessarily problematic. Bibliometric databases in the field of education include dissertations, technical reports, and unpublished conference papers.

[32] For example, two courses teach the same subject matter, but one course uses CBI (the experimental or treatment group) and one course uses conventional instruction (the control group). At the end of the treatment period students are given the same test and test performance is compared.

Although the Kulik and Kulik study synthesized findings for several educational levels, many findings for K-12 CBI were reported separately. Two examples and interpretations of K-12 effect size from this study are presented here. In the first example, the overall effect size for 68 studies on computer-assisted instruction at the precollege level was 0.36. Because effect size is a standardized value based on the normal distribution and standard deviation, it can be interpreted as a z-score and converted to a percentile equivalent. A z-score of 0.36 is equivalent to the 64th percentile; students using CBI scored (on average) in the 64th percentile on measures of learning and achievement compared to the 50th percentile for students in a traditionally taught class.[33]

Obviously, factors other than CBI could have influenced these learning outcomes. Of the nine major categories of variables that Kulik and Kulik evaluated as alternative predictors of effect size, four were statistically significant influences: the type of application, the duration of instruction, the year of research publication, and the publication status of the research.[34] Effect sizes were systematically higher for:

- computer-assisted instruction (as opposed to computer-managed or computer-enriched instruction),
- instruction periods of four weeks or less in duration,
- reports published before 1970, and
- published research.

These findings are somewhat suggestive, since they indicate that (1) some types of CBI may be more effective than others (at least given existing courseware), (2) learning effects may diminish when computers are used for long periods, (3) there may be "novelty" learning effects associated

Text table 8-6.
Typical study features accounted for in computer-based instruction meta-analyses

Kulik and Kulik	Ryan
Type of application (computer-assisted instruction, computer-managed instruction, computer-enriched instruction)	**Student features** (grade level, socioeconomic status, school type, school area, ability level)
Duration of instruction (four weeks or less, more than four weeks)	**Computer hardware** (computer make, color monitor, music and sound, synthesized speech, input devices)
Type of computer interaction (off-line, terminal with mainframe, microcomputer)	**Software** (subject area, source, type of application—e.g., drill and practice, simulation, tutorial)
Subject assignment to study groups (random, nonrandom quasi-experimental design)	**Size of instructional unit**
Instructor effects (same instructor for experimental and control groups, different instructors for experimental and control groups)	**Physical setting** (type of communication, type of room)
Test bias (commercial standardized test, locally developed test)	**Duration of instruction** (duration of treatment, length of sessions, frequency of sessions)
Course content (mathematics, science, social science, reading and language, combined subjects, vocational training, other)	**Instructor features** (professional level, hours of pretraining)
Year of report[a]	**Methodological features** (subject assignment, instructor effects, test-author bias)
Source of study findings (e.g., technical report, dissertation, article, book, etc.)	**Year of report**[a]
	Source of study findings (e.g., technical report, dissertation, article, book, etc.)

[a]Year of report can be used as a proxy for the age, or "vintage," of the computer equipment.

SOURCES: C.-L. Kulik and J.A. Kulik, "Effectiveness of Computer-Based Instruction: An Updated Analysis," *Computers in Human Behavior*, Vol. 7 (1991): 75-94; and A. Ryan, "Meta-Analysis of Achievement Effects of Microcomputer Applications in Elementary Schools," *Educational Administration Quarterly*, Vol. 27, No. 2 (May): 161-84.

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with computer use,[35] and (4) not all CBI has a demonstrable achievement effect.

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[33] Note that students in a conventionally taught course are the control group. Assuming a normal distribution of test scores, the average test score (the mean) of this group represents the 50th percentile: one-half of all students score above the mean, and one-half score below the mean. The z-score that corresponds to the mean of a normal distribution is zero, so the effect of CBI would be zero because it is not used in the control group.

[34] Statistical significance means that the average response (e.g., test score) is distinctly different between the groups in question. Tests of statistical significance are based on probability theory.

As a second example of meta-analysis, effect sizes for specific academic subjects varied from 0.10 for science (54th percentile), 0.25 for reading and language (60th percentile), and 0.37 for mathematics (64th percentile). Although it may be tempting to conclude from these metrics that CBI is more effective for mathematics than other subjects, these subject matter differences in effect size were not statistically significant in the meta-analysis.

When presented as percentile equivalents or as fractions of a standard deviation, gains in computer-assisted instruction appear modest. Another way of interpreting meta-analysis effect size is as grade-equivalent scores, which provide a more concrete sense of impact (Ryan 1991). Glass, McGaw, and Smith (1981) report that in elementary school grade levels, the standard deviation on most achievement tests is the equivalent of one grade level. As a consequence, a 0.36 effect size, which is equivalent to 0.36 standard deviations, represents a gain of about 3 to 4 months of instruction, assuming the school year is about 9 to 10 months long. This indicates that about three to four months' more learning occurred than could generally be expected in a school year. However, because the Kulik and Kulik effect sizes reported above are for both elementary and secondary schools, they cannot be interpreted in grade-equivalent gains.

Ryan's (1991) meta-analysis of the effects of microcomputers on kindergarten through sixth grade achievement can be reported on a grade-equivalent basis. Her meta-analysis of 40 studies[36] conducted between 1984 and 1989 found an overall effect size of 0.309. Thus, the average K-6 student using a microcomputer as an instructional tool performed in the 62nd percentile on tests, compared to the 50th percentile for the average K-6 student who did not use a microcomputer. Ryan explains that

> the effect size of .309 means that the effect of computer instruction is approximately one-third greater than the effect of control group instruction. In terms of grade-equivalent units, .309 can be interpreted as one third greater than the expected gain in a school year, approximately 3 months additional gain in [grade level]" (p. 171).

Ryan likewise evaluated several sets of variables other than CBI that may have had an impact on effect size. (See text table 8-6.) Of these variables, only the degree of teacher pretraining was statistically significant. In experimental groups where teachers had fewer than 10 hours of computer pretraining, the effect size of CBI was negligible and, in some instances, negative. In groups where teacher pretraining exceeded 10 hours, the effect size was 0.53, equivalent to one-half a school year gain, or 70th percentile performance. Ryan's findings reinforce other studies that identify the crucial role of teacher preparedness in effective CBI (U.S. OTA 1995 and PCAST 1997).

Computers and Alternative Instruction

Computer-based instruction can also be incorporated into enriched learning environments. Isolating the effects of computers in these alternative approaches to education is difficult, but the positive impacts of the full instructional package for several special projects merit note. One is the Higher Order Thinking Skills (HOTS) Program, an intervention program for economically disadvantaged students in the fourth through seventh grades. Students were taken from their traditional classrooms and taught through an innovative curriculum that integrated computer-assisted instruction, drama, and Socratic method. Students in the HOTS Program outperformed other disadvantaged students in a control group on all measures and had double the national average gains on standardized tests in reading and mathematics (Costa and Liebmann 1997). The Buddy Project in Indiana, in which students in some classrooms were given home computers, also reported highly positive results across a variety of skills. Similar results were reported for the Computers Helping Instruction and Learning Development in Florida, an elementary school program that emphasized student empowerment, teacher training and teamwork, and independent learning (ETS 1997). These studies suggest that the use of computers in enriched, nontraditional learning environments might achieve the fundamental changes in student learning that advocates of computer-based instruction desire.

IT and the Citizen

Access to information and proficiency with information technologies could potentially influence an individual's well-being. Employability and income are tied increasingly to computer training and literacy, and a home computer could enable families to change their work patterns through telecommuting. (See "Trends in Telecommuting.") Because of the rapidly expanding variety of services offered on the Internet and World Wide Web, information access might also play a growing role in medical care,[37] civic and political participation, lifelong learning, recreation and leisure activities, and personal finance. In short, information consumption, use of IT, and effective "knowledge management" could become increasingly instrumental to health, wealth, power, and overall quality of life.

The growing significance of information raises questions about the equity of access to information technologies. In addition, the steady growth of databases about individual citizens—and the power of IT to combine those data into

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[35] The higher effect sizes for studies published before 1970 are intriguing, and may reflect novelty impacts. Such effects result from the greater attention and effort an individual gives to a substantially new technology and not necessarily from any intrinsic contributions of the technology itself.

[36] Ryan also had a precise set of stringent selection criteria, including the requirements that the study reflect experimental or quasi-experimental design, that the sample size be at least 40 students (a minimum of 20 students in the treatment and control groups), and that the treatment last eight weeks or longer.

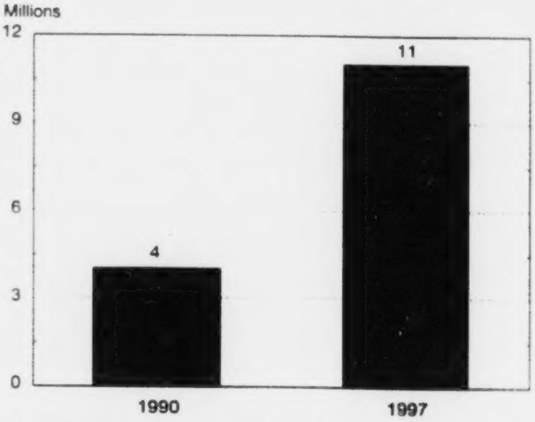
[37] Survey data indicate that people are increasingly using the World Wide Web for health-related information. See chapter 7, "The Use of Computer Technology in the United States."

Trends in Telecommuting

Telecommuting is considered to be one of the more positive benefits of IT and networks. Working from home alleviates traffic congestion, accommodates family schedules, and enhances white-collar productivity. Telecommuting is promoted by such corporate giants as Motorola, AT&T, Sun Microsystems, IBM, Ernst and Young, and Hewlett Packard. Corporate telecommuters work almost half of their work week at home (about 19 hours).

The number of individuals who reported working as telecommuters in 1997 was 11 million, just under 10 percent of the U.S. labor force. (See figure 8-18.) The total is growing rapidly, however, at about 15 percent a year. Some analysts estimate that at least 40 percent of today's workers could be telecommuters at least part of the time. For these statistics and others, see Telecommute America (1997).

Figure 8-18.
Number of telecommuters in the United States



SOURCE: Telecommute America, "News Release July 2, 1997" <<http://www.att.com/press/0767/970702.bsa.html#facts>>.

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highly revealing portraits about an individual—presents the possibility that rather than enhance personal liberty and well-being, information will instead tyrannize the private citizen. Although scholars have as yet found little evidence that the Internet changes the dynamics of democratic governance and discourse (see King and Kraemer 1997), the volume of data collected on private individuals without their consent has increased. This section therefore examines the impacts of IT on two dimensions of civil life: equity of opportunity and personal privacy. Note, however, that these are only two of the many ways in which IT may affect individuals. Other issues of interest include the role of information for personal empowerment and quality of life, the impact of IT on government services and public access to government services, and the potential impact of IT on human cognition and thinking processes.

Equity Issues

Equality of opportunity is a hallmark of U.S. political culture and reflects a national commitment to minimize structural barriers to personal achievement.[38] With respect to education and IT, equity is of particular concern not only because of the importance of training an adequately prepared workforce, but also because (as reviewed earlier) use of IT can affect children's learning ability. Personal and household access to computers and the Internet facilitates distance education, access to health information and government services, and job searches in classified ads. Inequality of information access and IT literacy could aggravate existing race, ethnic, and class divisions in the United States; conversely, equality of information access and information skills could help integrate ethnic groups, the poor, and rural communities into the economic and political systems.

Educational Inequities

Diffusion data indicate that pronounced educational inequalities in access to IT exist—key (and interrelated) determinants of access are income, race, and ethnicity. Schools with white, affluent, and suburban students have the greatest levels of IT adoption; schools with poor and minority students have considerably lower IT adoption rates. Inequities in access to IT may be particularly difficult to overcome when considered in the context of major inequalities in school facilities, resources, teacher training, and curriculum among ethnic minorities and the poor (Kozol 1991).

Differences exist in student computer use by race or ethnic group and grade level. (See figure 8-19.) At the elementary school level (grades 1-8), inequalities are particularly pronounced. While nearly three-quarters of all white elementary school children used computers at school in 1993, fewer than two-thirds of black and Hispanic children did. Because elementary school use of computers is particularly focused on drill-and-practice activities in mathematics and reading, the data suggest that minority children are getting less computer-reinforced training in basic skills than their white counterparts. Although inequalities in computer use diminish by high school—about 55 percent of black and Hispanic teenagers use computers at school, compared to 60 percent of white teens—variations in the content of that use are notable. For example, college-bound minority students get less experience in all major areas of computing applications than college-bound whites except data processing and computer programming.

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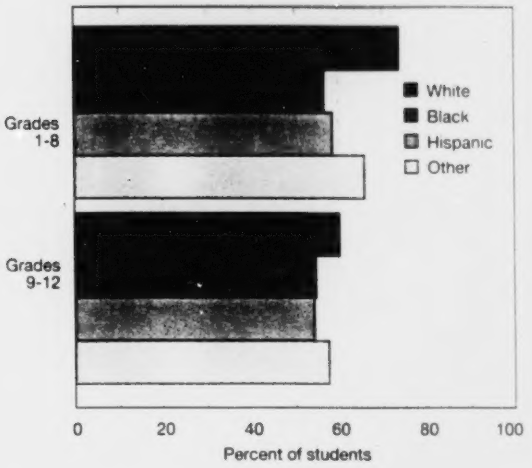
[38] Structural barriers may reflect deliberate discrimination (such as hiring and promotion practices) as well as nondiscriminatory but excessively inequitable treatment (such as variations in school funding within a school district). In some instances, equal opportunity may also involve proactive efforts to correct inequalities among disadvantaged groups.

Figure 8-19.
Student use of computers at school, by grade level and race/ethnicity: 1993



See appendix table 8-8. *Science & Engineering Indicators – 1998*

(See figure 8-20.) Female students get less experience than males in all applications except word processing and use in English courses.

These inequities in computer use at the elementary and high school levels could be the result of curriculum and teacher training as well as in-school access. As discussed earlier, research shows that use of computing resources depends on a teacher's training and ability to integrate computer-based instruction into the existing curriculum. One government report finds some evidence of differences in computer training among teachers of different ethnicity and socioeconomic status (PCAST 1997); however, diffusion data suggest that differences in students' school use of IT depend upon the availability of the equipment itself. Citing data from Quality Education Data, Inc., the Educational Testing Service (1997) notes that schools with a minority population of less than 25 percent have student-to-computer ratios of about 10 to 1, while schools with 90 percent or more minority students have ratios of 17.4 to 1. Similarly, the National Center for Education Statistics (1997) reports that schools with 50 percent or more minority students have Internet access in only 5 percent of their instructional classrooms, compared to 18 percent in schools with minority populations of 20 percent or less.

As with race and ethnicity, income is associated with student computer use. In 1993, three-quarters of all elementary school children from households with incomes greater than $50,000 used a computer at school, compared to two-thirds (or below) for children from households with incomes lower than $20,000. (See figure 8-21.) Internet access is similarly inequitable. Schools that have the largest proportion of economically disadvantaged students have less than one-half the level of Internet access as more affluent schools. (See figure 8-22 and figure 1-17 in chapter 1.) In short, schools with large minority and poor populations have less access to all information technologies, including multimedia computers, cable TV, Internet hook-ups, interactive videodisk, CD-ROMs, and satellite connections (ETS 1997).

Household Inequities

Inequality of access to information technologies applies to adults as well as children. In 1993, about a third more whites used computers at work than blacks, and over a half more whites used computers at work than Hispanics. (See figure 8-23.) The disparity is even more pronounced regarding home use. The percentage of whites with a computer at home is twice that of blacks or Hispanics.[39]

There appears to be a distinct class of "IT-disadvantaged" citizens. Adults who have not graduated from high school have one-fourth the level of ownership of home computers compared to those individuals with graduate or professional degrees. (See figure 8-24.) And the lowest income groups report one-ninth the level of computer ownership compared to individuals in the highest income brackets. (See figure 8-25.) Children share in this household inequity; more than 10 times as many of the most well-off children use computers at home as do the poorest students—more than 60 percent compared to about 5 percent. (See appendix table 8-8.)

Geographic data shed light on the informationally disadvantaged. The National Telecommunications and Information Administration (NTIA) finds that "in essence, information 'have nots' are disproportionately found in this country's rural areas *and* its central cities, [however] no situation compares with the plight of the rural poor" (NTIA 1995). Only 5 percent of rural households with annual incomes of less than $10,000 have computers—the lowest rate of ownership for any group. (See figure 8-26.) Unfortunately, these households cannot compensate for their lack of information access at home by using public libraries. As noted earlier, fewer than one-third of the libraries that serve communities of less than 5,000 have Internet access, compared to 93 percent of the libraries in metropolitan areas of 100,000 or more.

The irony of limited access by the poor, the least educated, and rural communities to information technologies is that when these groups gain access to IT and networks, they use the technology for self-advancement. NTIA reports that:

> Many of the groups that are the most disadvantaged in terms of absolute computer and modem penetration are the most enthusiastic users of on-line services that facilitate economic uplift and empowerment. [Census survey data reveal that] low-income, minority, young, and less-educated computer households in rural areas and central cities appear to be likely to engage actively in searching classified ads for employment, taking educational classes, and accessing government reports, on-line via modem (1995, p. 3).

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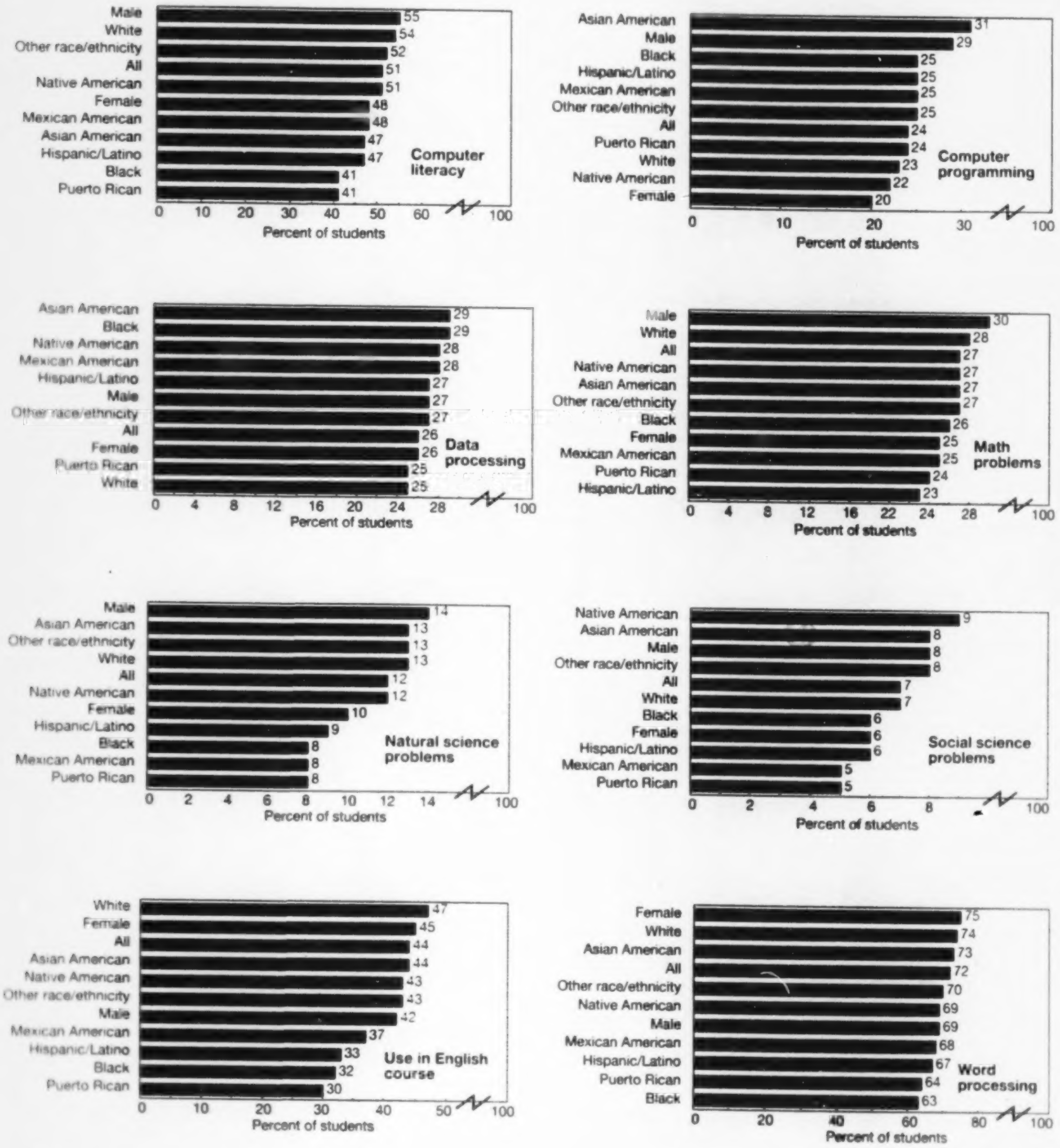
[39] Note that white, black, and Hispanic computer owners *do* tend to have comparable technological access to networks; there are no meaningful differences among racial and ethnic groups in terms of whether their computers have modems. See NTIA (1995).

Figure 8-20.

Computer-related experience of college-bound seniors, by sex, race/ethnicity, and computing applications: 1996



NOTE: Data are for college-bound seniors who took the SAT.

SOURCE: Educational Testing Service, *Computers and Classrooms: The Status of Technology in US Schools, Policy Information Report* (Princeton: Educational Testing Service, Policy Information Center, 1997); data from The College Board.

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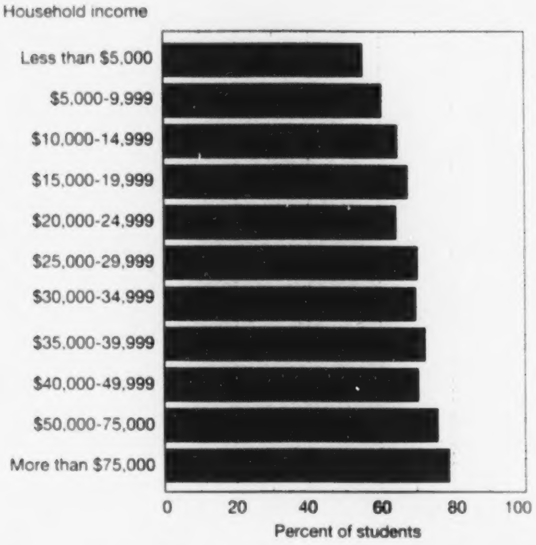
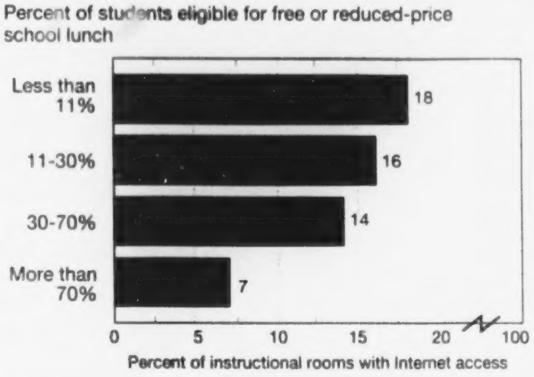
Figure 8-21.
Student use of computers at school, grades 1-8, by level of household income: 1993



See appendix table 8-8. *Science & Engineering Indicators – 1998*

Figure 8-22.
Level of Internet access in schools by student body income level: 1996



SOURCE: National Center for Education Statistics, "Advanced Telecommunications in U.S. Public Elementary and Secondary Schools, Fall 1996," *Statistics in Brief*, NCES 97-944 (Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement, 1997).

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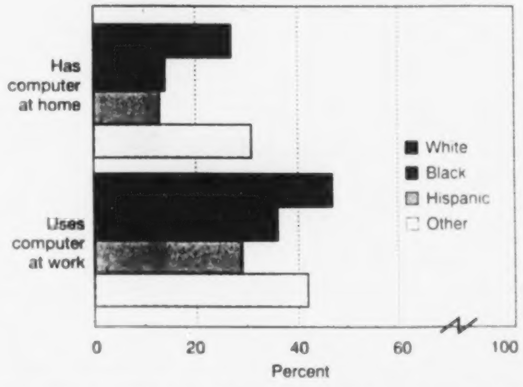
Bier et al. (1996) found similar results in a well-structured ethnographic study of home Internet use by six low-income families in Florida. These families were provided with home computers and Internet access to "see what families designated as 'informationally disadvantaged' would actually do on-line given unrestricted home Internet access" (p. 1). Families in the study used their computers and the Internet to acquire health information, create network support groups, search for jobs, and do school work.[40] Individuals reported growth in their self-esteem, better grades, more effective communications with physicians, and closer relationships with their children. They also spoke of their fear of losing the technology because of the temporary nature of the study. As the authors summarize:

> We did not anticipate the profound ways in which our participants' interactions with the technology and the relationships it made possible would change them, their sense of identity, and the content of their lives. While these changes were perceived as positive by the participants, our dilemma arose when participants began to express their growing fear of the time when they would be expected to return the borrowed equipment…According to use of human subjects research codes we met our ethical responsibility to the participants by clearly delineating the temporary nature of the resources provided…However, we have come to feel that adherence to these standard ethical requirements is insufficient to adequately address the principle of reciprocity in our relationships…In this study it became important…to actively support the positive potential awakened in the participants (p. 9).

Privacy Issues

IT offers extraordinary potential for collecting and reporting detailed information about individuals that many would consider to be private. Information on medical histories, credit records, shopping habits, spending practices, income levels, magazine subscriptions, video rentals, vacation preferences, and

Figure 8-23.
Proportion of adults who use computers at home and at work, by race/ethnicity: 1993



See appendix table 8-9. *Science & Engineering Indicators – 1998*

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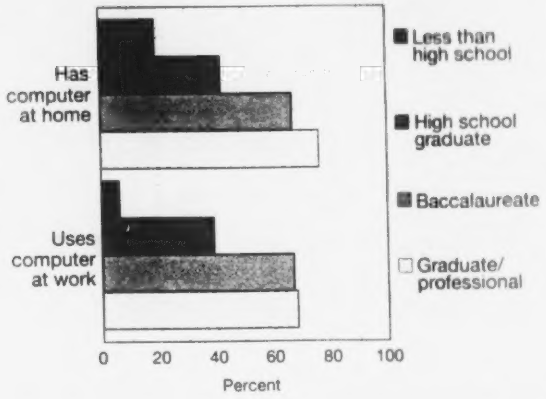
[40] The authors state that "participants made use of virtual hospitals, medical dictionaries, and physician desk references. They joined support groups, visited international zoos, investigated scholarships, and made local transportation arrangements. They investigated appliances, looked at employment listings, and kept up with the local calendar of events" (Bier et al 1996, p. 3).

Figure 8-24.
Proportion of adults who use computers at home and at work, by level of formal education: 1997



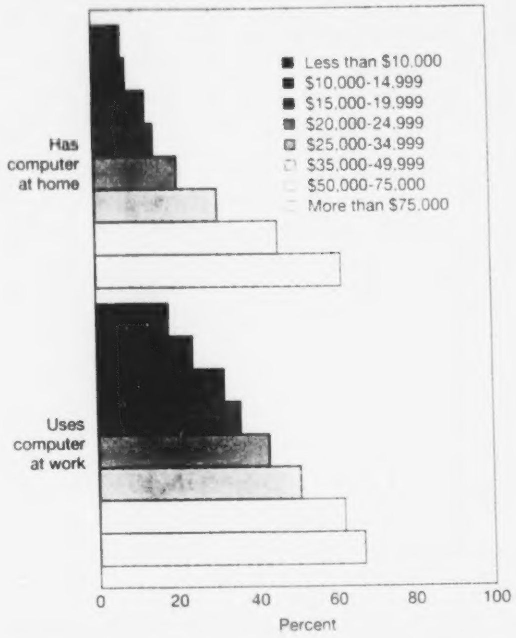
See appendix table 7-26. *Science & Engineering Indicators – 1998*

even coupon usage is routinely collected by commercial enterprises and stored in databases. These databases are, in turn, sold, bought, and "overlayed" into detailed electronic files on millions of individuals. With no more information than a name, address, phone number, or birthdate, a persistent "data miner" can compile a dossier with detail and scope that would shock most individuals. The proliferation and commercialization of personal data and information—and the fact that it is happening without the consent of the individual—has been well-documented (Smith 1994, Kahin and Nesson 1997, Regan 1995, Cavoukian and Tapscott 1997, and Culnan 1991). Other IT-related privacy issues include (but are not limited to) surveillance in the workplace (e.g., reading employees' e-mail and listening to their telephone calls) and tracking a person's Internet activities through an electronic tracer known as a "cookie."

Not surprisingly, Americans' concerns about protecting the privacy of their personal information and communications have been rising steadily for the past two decades. Concerns are sufficiently intense that more than a dozen pieces of related legislation have been passed since the 1970s (see Regan 1995 for a review). In addition, in 1994, Wisconsin became the first state in the country to establish an Office of the Privacy Advocate for its citizens, a bureau that actively promotes the protection of "personally identifiable" information.

Empirical measures of the proliferation of private information are not available. In addition, it is difficult to establish objective measures of violations of privacy, since privacy represents both values and psychological states. (In other words, violations of privacy are largely in the eye of the beholder.) If legal criteria are used—such as those of the 1974 Privacy Act, which essentially states that data cannot be collected on individuals without their permission—then we would be forced to conclude that violations of privacy are in fact commonplace.

Figure 8-25.
Proportion of adults who use computers at home and at work, by income level: 1993



See appendix table 8-9. *Science & Engineering Indicators – 1998*

Easier to measure is a society's collective sense about privacy and its safeguards. A variety of public opinion polls regarding privacy have been administered over the past 15 years, and they document a public concern over privacy that is growing in scope and intensity. By the mid-1990s, more people registered stronger concerns about protecting their privacy than at any other time. For example, the 1996 Equifax/Harris Consumer Privacy Survey found that 65 percent of those polled reported that protecting the privacy of consumer information was very important to them—an increase of 4 percentage points over the previous year (Equifax 1997).[41] Medical privacy appears to be of particular concern (NRC 1997). In 1993, 96 percent of those surveyed believed that "federal legislation should designate all personal medical information as 'sensitive' and impose penalties for unauthorized disclosure."[42] Confidence in controls on information marketing is not strong, however. In 1993, nearly half of all respondents to the Equifax/Harris survey indicated that they agreed strongly with the statement that "consumers have lost all control over how personal information about them is

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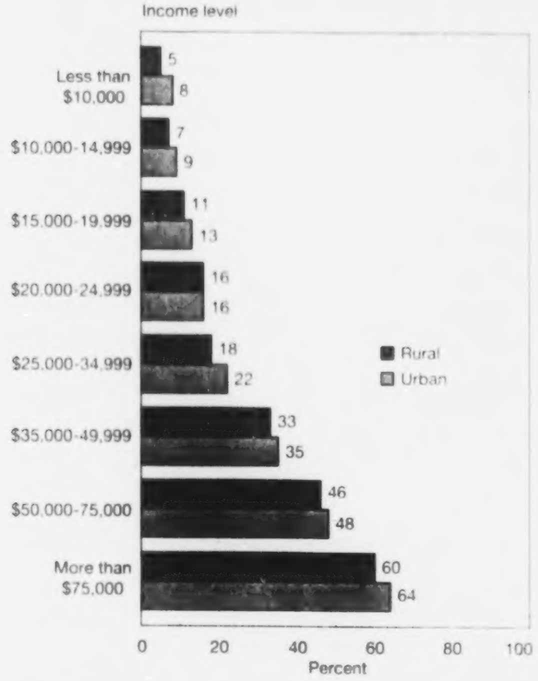
[41] The wording of the Equifax/Harris polls has changed over time, making direct comparisons across multiple years difficult. Analysts do, however, conclude that the trend in public opinion is distinctly toward greater and more intense concerns over violations of privacy (Regan 1995, and Cavoukian and Tapscott 1997).

[42] Based on the 1993 Equifax/Harris Health Information Privacy Survey. See EPIC (1997).

Figure 8-26.
Percentage of U.S. households with a computer, by income level and geographic location: 1994



NOTE: "Rural" reflects populations of less than 2,500 persons; "urban" reflects populations of more than 2,500 persons.

SOURCE: National Telecommunications and Information Administration, *Falling Through the Net: A Survey of the "Have Nots" in Rural and Urban America*, <<http://www.ntia.doc.gov/ntiahome/fallingthru.html>> (August 1997); table can be accessed at <<http://www.ntia.doc.gov/ntiahome/tables.html>>. Data are based on the U.S. Bureau of the Census, Current Population Survey, November 1994.

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circulated and used by companies," a response 27 percent higher than that reported just two years previously (Regan 1995). In addition, 60 percent of those surveyed in an American Civil Liberties Union poll believe that their health insurance data are being accessed by others for secondary uses (EPIC 1997).

Americans strongly believe in their right to information privacy. Ninety-three percent of respondents in a 1991 Time-CNN poll believed that "companies that sell information to others should be required by law to ask permission from individuals before making the information available." The vast majority of people believe that companies should be prohibited from selling information about household income (90 percent), bill-paying history (86 percent), and product purchases (68 percent) (EPIC 1996). With respect to Internet use, the 1996 Georgia Tech Fifth World Wide Web Poll revealed that on-line Web users almost unanimously valued the ability to visit Web sites anonymously (rating this item as 4.6 on a scale of 5), and strongly opposed the right of site providers to sell information about their users to other companies (rating the right to sell at 1.7 on a scale of 5) (EPIC 1996).

Conclusion

The Need for IT Metrics

Metrics are a form of information and are ideally developed to answer specific sorts of questions. Which measures a society collects and analyzes about the effects of a technology depends largely upon what it wants to know, and we would not expect that all societies necessarily want to know the same things. The metrics and analyses presented here are based on four central questions:

- How extensively is IT embedded in American society?
- How is IT being used for business, educational, and other needs?
- What are the positive consequences of this use?
- What are the warning signals about the negative consequences of this use?

Available metrics exhibit considerable weaknesses in their ability to answer the above questions. The single most important obstacle to effective data collection is the lack of standardized definitions of IT, and the exclusion of important costs associated with IT use. For example, in some economic studies, IT reflects only computers, while in others it captures computers and telecommunications hardware. Research shows that IT support personnel and training expenses are significant elements of the cost and effective use of IT, but that these expenses are not always included in research studies or data collection. To fully capture the extent of the technology, IT should be defined as computers and telecommunications equipment. In addition, IT-associated costs should be included when collecting expenditure data on IT. Key associated costs include software, personnel expenses for IT support staff (e.g., network administrators), and training expenses for individuals who use the technology. One major obstacle to more effective data collection is the lack of appropriate budgeting and accounting reporting systems at the organizational level. Another is that IT itself continues to change rapidly.

A further weakness is the relative absence of systematic information on how IT is actually being used. IT is a means to an end—principally information processing. A real appreciation for the impacts and consequences of IT requires understanding what information it allows us to collect, access, and process. The presence of the hardware itself does not tell us to what ends it is put, and it is the actual use of the technology that determines its effects. Systematic surveys of IT applications are thus in order. For example, time-on-task audits would reveal how individuals actually use computers and networks at their office, school, or home; analytical questions about the impacts of specific IT activities would develop from patterns of real use. Similarly, diffusion estimates for specific types of applications (such as CAD-CAM, electronic data interchange, inventory management systems, and business management systems) could narrow down and help identify impact-related questions. Systematic knowledge

Text table 8-7.
Viable information technologies metrics

Metric	Source of data	Comments
IT investments in industry (diffusion indicator)	U.S. Bureau of Economic Analysis	Investments in IT disaggregated by type of technology. Reported as an annual investment as well as capital stock at the individual industry level.
IT hardware in K-12 schools (diffusion indicator)	Quality Education Data Inc., Denver, CO	Investments in several types of IT (computers, satellites, CD-ROMs, etc.) by school and location. Contains detailed data about school demographics.
K-12 Internet access (diffusion indicator)	National Center for Education Statistics	Extent of Internet access by type of school and location; contains detailed data about school demographics.
Library Internet access	American Library Association	Extent of Internet access by libraries (public and academic). Detailed data on size of community library services.
Individual perceptions of privacy (impact indicator)	Equifax/Harris Survey	Time-series data on public perceptions about violations of information privacy and rights to information privacy.
Patterns of individual use of the World Wide Web (usage indicator)	Georgia Tech Internet Survey	How individuals use the Internet and values about access to information.

IT = information technologies

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about the degree of importance of different uses and applications of IT is missing.

Recommendations for IT Metrics

Diffusion indicators for IT are relatively abundant and analytically useful. Several good data series exist that could be compiled into an ongoing set of diffusion metrics. These indicators are presented in text table 8-7, and include IT investments and stocks by industry and IT in K-12 schools. A lack of diffusion/IT intensity metrics is notable for both the education and economic sectors with respect to IT-associated costs—personnel, software, and training. These IT expenses are emerging in the research as significant determinants of IT effectiveness, and need to be tracked on a systematic basis. The most striking lack of data relates to distance education: by definition, this is learning that takes place through the use of information technologies, and there are simply no reliable metrics on the scope and growth of this unique educational practice.

Impact measures for the economy are problematic, primarily because of the difficulty in measuring economic output for many of the service sectors. One alternative to this dilemma is to select a representative set of sectors—or those that are the most economically significant—and develop a set of impact metrics unique to each. The research evidence suggests that IT impacts are highly firm- and industry-specific; it is unlikely that a single measure could capture the economic benefits of IT for all types of enterprises. Three potential measures—as illustrated by the banking industry—are those that reflect the volume of transactions processing, human versus electronic transaction costs for key types of transactions, and processing times for key transactions.

Impact assessments for IT and learning are complicated by a more severe measurement issue, which is the need to collect data through observational studies or controlled experiments. Meta-analysis suggests that computer-based instruction generates real learning impacts, but more rigorous and comprehensive studies need to be conducted. A large-scale controlled study would be one way to avoid the statistical dilemmas of small classroom experiments.

Finally, IT clearly raises quality-of-life issues for the individual citizen. Occupational injury, psychological stress, and violations of privacy are clearly potential dangers of the widespread use of information technologies in the workplace and in information-intensive industries. Consistent tracking of the hazards to the individual represented by extensive use of IT is in order. Because IT also can clearly enhance quality of life, inequity in IT access could create more social stratification in the United States. Ongoing monitoring of equity indicators is critical as the significance of IT to employment, health, and well-being grows.

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Appendix A
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Appendix table 1-1.

Proportion of high school graduates earning credits in science courses, by sex: 1982, 1987, 1990, and 1994

(Percentages)

Year of graduation and sex	Any science	Survey science	Biology	AP/honors biology	Chemistry	AP chemistry	Physics	AP/honors physics
1982 graduates								
All	96.5 (0.3)	62.1 (1.2)	76.6 (0.8)	9.7 (0.5)	31.1 (0.8)	3.0 (0.4)	14.4 (0.5)	1.1 (0.1)
Male	96.3 (0.3)	63.6 (1.4)	74.5 (0.9)	9.0 (0.5)	32.2 (1.2)	3.5 (0.5)	19.1 (1.0)	1.5 (0.2)
Female	96.7 (0.3)	60.8 (1.3)	78.6 (1.1)	10.3 (0.8)	30.2 (0.7)	2.4 (0.5)	10.2 (0.4)	0.7 (0.1)
1987 graduates								
All	99.1 (0.2)	61.3 (3.1)	87.9 (1.0)	9.5 (0.8)	43.8 (1.1)	3.3 (0.4)	19.3 (0.9)	1.7 (0.3)
Male	98.8 (0.2)	61.8 (3.0)	86.3 (1.2)	9.4 (0.8)	44.3 (1.3)	3.9 (0.5)	24.1 (1.0)	2.5 (0.4)
Female	99.3 (0.1)	60.7 (3.3)	89.5 (0.8)	9.6 (1.0)	43.2 (1.2)	2.7 (0.3)	14.7 (0.9)	0.9 (0.2)
1990 graduates								
All	99.4 (0.1)	68.1 (1.8)	91.1 (1.0)	10.1 (1.0)	48.9 (1.3)	3.5 (0.5)	21.6 (0.8)	2.0 (0.4)
Male	99.1 (0.3)	69.6 (1.9)	89.6 (1.1)	9.3 (1.0)	47.7 (1.4)	4.1 (0.5)	25.4 (0.9)	2.5 (0.5)
Female	99.7 (0.1)	66.7 (1.9)	92.4 (0.9)	10.8 (1.2)	50.0 (1.3)	2.9 (0.5)	18.0 (0.9)	1.6 (0.3)
1994 graduates								
All	99.6 (0.1)	71.2 (2.0)	93.4 (1.0)	11.8 (0.9)	55.7 (1.1)	4.0 (0.5)	24.6 (0.8)	2.7 (0.3)
Male	99.5 (0.2)	72.6 (2.0)	92.0 (1.1)	10.9 (0.9)	52.8 (1.1)	4.1 (0.6)	27.1 (1.0)	3.4 (0.4)
Female	99.8 (0.1)	69.9 (2.1)	94.7 (0.9)	12.7 (1.1)	58.5 (1.2)	3.7 (0.5)	22.2 (0.9)	2.0 (0.3)

AP = advanced placement

NOTE: Standard errors are shown in parentheses.

SOURCE: National Center for Education Statistics, *The 1994 High School Transcript Study Tabulations: Comparative Data on Credits Earned and Demographics for 1994, 1990, 1987, and 1982 High School Graduates*, NCES 97-260 (Washington, DC: U.S. Department of Education, 1997).

See figure 1-1.

Science & Engineering Indicators – 1998

Appendix table 1-2.
Proportion of high school graduates earning credits in science courses, by race/ethnicity: 1982, 1987, 1990, and 1994
(Percentages)

Year of graduation and race/ethnicity	Any science	Survey science	Biology	AP/honors biology	Chemistry	AP chemistry	Physics	AP/honors physics
1982 graduates								
White	96.9 (0.3)	61.6 (1.4)	78.6 (1.0)	10.9 (0.7)	34.4 (0.9)	3.3 (0.5)	16.5 (0.6)	1.2 (0.2)
Asian/Pacific Islander	95.9 (1.3)	40.9 (5.1)	83.7 (2.2)	17.5 (2.9)	52.8 (4.4)	5.8 (1.3)	34.8 (3.4)	3.4 (1.0)
Black	97.1 (0.5)	67.8 (1.8)	73.0 (1.9)	6.0 (1.3)	22.3 (1.5)	1.6 (0.6)	7.6 (0.8)	0.9 (0.4)
Hispanic	93.5 (1.1)	63.3 (1.6)	68.6 (2.1)	4.8 (0.7)	15.6 (1.0)	1.4 (0.4)	5.6 (0.6)	0.4 (0.1)
Native American	91.6 (4.9)	58.1 (7.7)	67.4 (7.0)	3.2 (1.8)	26.2 (7.0)	0.9 (0.9)	8.2 (3.1)	0.0 (0.0)
1987 graduates								
White	99.2 (0.2)	60.7 (3.6)	88.8 (1.1)	9.6 (0.9)	46.7 (1.2)	3.4 (0.4)	20.6 (1.0)	1.7 (0.3)
Asian/Pacific Islander	99.6 (0.3)	44.8 (5.2)	92.1 (1.3)	23.6 (4.4)	70.2 (3.7)	15.4 (2.5)	46.9 (4.2)	6.2 (1.4)
Black	99.0 (0.3)	71.8 (3.8)	84.6 (1.8)	5.2 (0.7)	28.4 (1.8)	1.1 (0.3)	9.7 (1.1)	0.4 (0.1)
Hispanic	99.1 (0.3)	66.9 (3.2)	85.5 (1.5)	7.6 (1.1)	29.1 (1.5)	2.2 (0.6)	9.9 (1.1)	0.8 (0.3)
Native American	99.1 (0.7)	67.3 (3.3)	90.9 (1.9)	13.0 (3.6)	26.4 (2.0)	0.6 (0.3)	8.4 (2.4)	1.4 (0.5)
1990 graduates								
White	99.4 (0.2)	67.6 (2.0)	91.3 (1.1)	10.5 (1.0)	51.4 (1.4)	3.7 (0.6)	23.1 (0.9)	2.1 (0.4)
Asian/Pacific Islander	99.6 (0.2)	56.7 (7.1)	90.4 (2.7)	13.4 (4.0)	63.6 (4.0)	7.7 (1.9)	38.4 (3.5)	5.9 (2.6)
Black	99.5 (0.2)	75.3 (3.1)	91.1 (2.2)	7.7 (1.9)	40.0 (2.2)	2.5 (0.9)	14.5 (1.9)	0.7 (0.3)
Hispanic	99.1 (0.3)	72.0 (3.5)	90.1 (1.4)	6.7 (1.3)	38.1 (2.9)	1.1 (0.4)	13.2 (1.3)	1.0 (0.4)
Native American	98.7 (1.2)	69.4 (5.8)	89.4 (4.7)	3.8 (2.0)	34.9 (4.6)	4.4 (2.6)	14.5 (3.8)	0.5 (0.5)
1994 graduates								
White	99.8 (0.1)	72.4 (2.3)	94.2 (1.2)	12.4 (1.1)	58.2 (1.1)	4.3 (0.6)	26.1 (1.0)	2.7 (0.4)
Asian/Pacific Islander	99.4 (0.4)	62.0 (4.5)	91.5 (1.4)	18.2 (3.1)	69.2 (4.8)	7.7 (1.5)	44.4 (3.7)	6.7 (1.5)
Black	99.8 (0.1)	71.7 (3.7)	91.8 (2.1)	7.7 (1.0)	43.7 (2.7)	2.1 (0.7)	15.0 (1.2)	1.8 (0.4)
Hispanic	99.3 (0.2)	69.7 (3.1)	93.7 (0.6)	11.0 (1.1)	46.0 (2.8)	2.5 (0.6)	16.1 (1.4)	1.9 (0.5)
Native American	99.7 (0.3)	79.0 (5.1)	91.8 (2.1)	6.2 (2.9)	41.3 (5.4)	0.6 (0.6)	10.3 (2.8)	0.3 (0.3)

AP = advanced placement

NOTE: Standard errors are shown in parentheses.

SOURCE: National Center for Education Statistics, *The 1994 High School Transcript Study Tabulations: Comparative Data on Credits Earned and Demographics for 1994, 1990, 1987, and 1982 High School Graduates*, NCES 97-260 (Washington, DC: U.S. Department of Education, 1997).

See figure 1-2.

Science & Engineering Indicators – 1998

Appendix table 1-3.

Trends in average scale scores on the National Assessment of Educational Progress in science, by age, sex, and race/ethnicity: 1969-96, selected years

	All students	Males	Females	Difference, male vs. female	Whites	Blacks	Difference, white vs. black	Hispanics	Difference, white vs. Hispanic
Age 9									
1970	225 (1.2)	228 (1.3)	223 (1.2)	5 (1.8)	236 (0.9)	179 (1.9)	57 (2.1)	NA	NA
1973	220 (1.2)	223 (1.3)	218 (1.2)	4 (1.8)	231 (0.9)	177 (1.9)	55 (2.1)	NA	NA
1977	220 (1.2)	222 (1.3)	218 (1.2)	5 (1.8)	230 (0.9)	175 (1.8)	55 (2.0)	192 (2.7)	38 (2.8)
1982	221 (1.8)	221 (2.3)	221 (2.0)	0 (3.0)	229 (1.9)	187 (3.0)	42 (3.6)	189 (4.2)	40 (4.6)
1986	224 (1.2)	227 (1.4)	221 (1.4)	6 (2.0)	232 (1.2)	196 (1.9)	36 (2.2)	199 (3.1)	33 (3.3)
1990	229 (0.8)	230 (1.1)	227 (1.0)	3 (1.5)	238 (0.8)	196 (2.0)	41 (2.1)	206 (2.2)	31 (2.4)
1992	231 (1.0)	235 (1.2)	227 (1.0)	8 (1.6)	239 (1.0)	200 (2.7)	39 (2.9)	205 (2.8)	34 (3.0)
1994	231 (1.2)	232 (1.3)	230 (1.4)	2 (1.9)	240 (1.3)	201 (1.7)	39 (2.2)	201 (2.7)	39 (3.0)
1996	230 (1.2)	232 (1.8)	228 (1.4)	4* (2.3)	239 (1.4)	201 (2.6)	38 (3.0)	207 (2.5)	33 (2.9)
Age 13									
1970	255 (1.1)	257 (1.3)	253 (1.2)	4 (1.8)	263 (0.8)	215 (2.4)	49 (2.5)	NA	NA
1973	250 (1.1)	252 (1.3)	247 (1.2)	5 (1.8)	259 (0.8)	205 (2.4)	53 (2.5)	NA	NA
1977	247 (1.1)	251 (1.3)	244 (1.2)	7 (1.7)	256 (0.8)	208 (2.4)	48 (2.5)	213 (1.9)	43 (2.1)
1982	250 (1.3)	256 (1.5)	245 (1.3)	11 (2.0)	257 (1.1)	217 (1.3)	40 (1.7)	226 (3.9)	32 (4.0)
1986	251 (1.4)	256 (1.6)	247 (1.5)	9 (2.2)	259 (1.4)	222 (2.5)	38 (2.9)	226 (3.1)	33 (3.4)
1990	255 (0.9)	259 (1.1)	252 (1.1)	7 (1.6)	264 (0.9)	226 (3.1)	38 (3.2)	232 (2.6)	33 (2.7)
1992	258 (0.8)	260 (1.2)	256 (1.0)	4 (1.6)	267 (1.0)	224 (2.7)	43 (2.9)	238 (2.6)	30 (2.8)
1994	257 (1.0)	259 (1.2)	254 (1.2)	5 (1.7)	267 (1.0)	224 (4.2)	43 (4.3)	232 (2.4)	34 (2.6)
1996	256 (1.0)	261 (1.1)	252 (1.3)	9* (1.7)	266 (1.2)	226 (2.2)	40 (2.5)	232 (2.5)	34 (2.7)
Age 17									
1969	305 (1.0)	314 (1.2)	297 (1.1)	17 (1.6)	312 (0.8)	258 (1.5)	54 (1.7)	NA	NA
1973	296 (1.0)	304 (1.2)	288 (1.1)	16 (1.6)	304 (0.8)	250 (1.5)	54 (1.7)	NA	NA
1977	290 (1.0)	297 (1.2)	282 (1.1)	15 (1.6)	298 (0.7)	240 (1.5)	57 (1.7)	262 (2.2)	35 (2.3)
1982	283 (1.2)	292 (1.4)	275 (1.3)	17 (1.9)	293 (1.0)	235 (1.7)	58 (2.0)	249 (2.3)	44 (2.5)
1986	289 (1.4)	295 (1.9)	282 (1.5)	13 (2.4)	298 (1.7)	253 (2.9)	45 (3.3)	259 (3.8)	38 (4.1)
1990	290 (1.1)	296 (1.3)	285 (1.6)	10 (2.1)	301 (1.1)	253 (4.5)	48 (4.6)	262 (4.4)	40 (4.5)
1992	294 (1.3)	299 (1.7)	289 (1.5)	19 (2.2)	304 (1.3)	256 (3.2)	48 (3.5)	270 (5.6)	34 (5.8)
1994	294 (1.6)	300 (2.0)	289 (1.7)	11 (2.6)	306 (1.5)	257 (3.1)	49 (3.5)	261 (6.7)	45 (6.9)
1996	296 (1.2)	300 (1.7)	292 (1.4)	8 (2.2)	307 (1.2)	260 (2.3)	47 (2.6)	269 (3.0)	38* (3.2)

* = average scale score difference in 1996 is significantly lower than in first year listed; NA = not available

NOTES: Scale scores range from 0 to 300 for every grade level. Standard errors are shown in parentheses.

SOURCE: J. Campbell, C. Reese, C. O'Sullivan, and J. Dossey, *NAEP 1994: Trends in Academic Progress* (Washington, DC: National Center for Education Statistics, 1996).

Science & Engineering Indicators – 1998

See figure 1-3.

Appendix table 1-4.

Grade 8 average scale scores on the National Assessment of Educational Progress in science, by state and race/ethnicity: 1996

State	All students		White		Asian/Pacific Islander		Black		Hispanic		Native American	
	Average scale score	Percentage of students	Average scale score	Percentage of students	Average scale score	Percentage of students	Average scale score	Percentage of students	Average scale score	Percentage of students	Average scale score	Percentage of students
Nation	148 (0.9)	100.0	159 (1.1)	68 (0.4)	150 (3.3)	2 (0.3)	120 (1.2)	15 (0.3)	127 (1.8)	12 (0.3)	148 (4.2)	2 (0.3)
Alabama	139 (1.6)	100.0	151 (1.5)	61 (1.9)	NA	NA	117 (1.8)	33 (1.9)	107 (7.6)	4 (0.4)	NA	NA
Alaska	153 (1.3)	100.0	162 (1.2)	66 (1.6)	152 (3.8)	7 (1.0)	*	4 (0.6)	137 (4.6)	7 (0.8)	129 (3.4)	16 (1.4)
Arizona	145 (1.6)	100.0	157 (1.3)	57 (1.9)	NA	NA	124 (3.3)	4 (0.6)	129 (2.1)	31 (1.6)	121 (8.6)	6 (1.5)
Arkansas	144 (1.3)	100.0	154 (1.5)	73 (1.9)	NA	NA	116 (2.5)	20 (1.7)	122 (5.8)	4 (0.5)	NA	NA
California	138 (1.7)	100.0	156 (1.7)	38 (2.1)	148 (3.6)	13 (1.4)	121 (3.4)	7 (1.0)	121 (1.9)	39 (1.8)	NA	NA
Colorado	155 (0.9)	100.0	162 (0.8)	70 (1.3)	155 (4.8)	3 (0.5)	142 (2.2)	5 (0.8)	135 (2.3)	20 (1.2)	142 (4.3)	3 (0.4)
Connecticut	155 (1.3)	100.0	165 (1.0)	75 (1.4)	163 (3.7)	3 (0.4)	121 (4.4)	10 (1.3)	122 (2.6)	11 (0.9)	NA	NA
Delaware	142 (0.8)	100.0	152 (0.8)	64 (1.2)	NA	NA	122 (1.8)	26 (1.0)	116 (4.1)	7 (0.7)	NA	NA
Florida	142 (1.6)	100.0	155 (1.5)	55 (2.1)	NA	NA	119 (2.7)	20 (2.0)	129 (2.2)	22 (2.0)	NA	NA
Georgia	142 (1.4)	100.0	155 (1.2)	56 (2.3)	NA	NA	122 (1.4)	36 (2.4)	128 (4.2)	5 (0.4)	NA	NA
Hawaii	135 (0.7)	100.0	146 (1.8)	17 (0.7)	138 (1.1)	54 (1.3)	128 (4.4)	3 (0.4)	121 (1.8)	22 (0.8)	NA	NA
Indiana	153 (1.4)	100.0	158 (1.3)	81 (1.8)	NA	NA	125 (3.3)	11 (1.4)	139 (2.1)	5 (0.7)	NA	NA
Iowa	158 (1.2)	100.0	160 (1.1)	91 (1.0)	NA	NA	131 (3.6)	3 (0.6)	140 (4.6)	3 (0.5)	NA	NA
Kentucky	147 (1.2)	100.0	151 (1.1)	86 (0.9)	NA	NA	127 (2.7)	9 (0.8)	113 (6.2)	3 (0.4)	NA	NA
Louisiana	132 (1.6)	100.0	148 (1.3)	55 (1.8)	NA	NA	113 (2.1)	37 (1.7)	104 (5.7)	6 (0.6)	NA	NA
Maine	163 (1.0)	100.0	164 (0.9)	92 (0.7)	NA	NA	*	1 (0.2)	141 (4.6)	3 (0.5)	NA	NA
Maryland	145 (1.5)	100.0	160 (1.4)	56 (2.0)	161 (3.6)	4 (0.6)	124 (1.4)	32 (2.1)	121 (4.1)	6 (0.6)	NA	NA
Massachusetts	157 (1.4)	100.0	163 (1.2)	81 (1.7)	152 (7.3)	4 (0.8)	126 (3.3)	6 (1.0)	126 (3.9)	8 (0.7)	NA	NA
Michigan	153 (1.4)	100.0	161 (1.4)	76 (2.0)	NA	NA	122 (2.4)	15 (1.9)	134 (4.9)	4 (0.4)	NA	NA
Minnesota	159 (1.3)	100.0	162 (1.2)	86 (1.9)	152 (9.7)	4 (0.9)	130 (4.4)	4 (0.8)	134 (5.3)	4 (0.6)	NA	NA
Mississippi	133 (1.4)	100.0	149 (1.2)	50 (2.1)	NA	NA	119 (1.4)	44 (1.9)	105 (3.8)	6 (0.6)	NA	NA
Missouri	151 (1.2)	100.0	158 (1.0)	78 (1.5)	NA	NA	120 (2.8)	13 (1.3)	130 (5.0)	5 (0.6)	NA	NA
Montana	162 (1.2)	100.0	166 (0.9)	83 (1.9)	NA	NA	*	1 (0.1)	147 (2.7)	5 (0.5)	139 (2.7)	10 (1.7)
Nebraska	157 (1.0)	100.0	161 (0.9)	85 (1.2)	NA	NA	130 (3.1)	5 (0.6)	134 (3.1)	7 (0.9)	NA	NA
New Mexico	141 (1.0)	100.0	159 (1.0)	38 (1.5)	NA	NA	*	3 (0.4)	130 (1.1)	51 (1.5)	126 (2.4)	8 (0.6)
New York	146 (1.6)	100.0	161 (1.4)	60 (2.6)	155 (5.4)	5 (0.9)	120 (1.9)	17 (2.0)	116 (2.7)	16 (1.2)	NA	NA
North Carolina	147 (1.2)	100.0	157 (1.1)	65 (2.0)	NA	NA	126 (1.4)	27 (1.3)	123 (3.6)	4 (0.5)	136 (4.1)	3 (1.4)
North Dakota	162 (0.8)	100.0	164 (0.8)	92 (0.8)	NA	NA	*	1 (0.2)	137 (4.5)	4 (0.4)	137 (6.9)	3 (0.7)
Oregon	155 (1.6)	100.0	158 (1.4)	82 (1.5)	157 (3.3)	4 (0.5)	*	2 (0.5)	133 (3.7)	8 (1.0)	142 (7.9)	4 (0.8)
Rhode Island	149 (0.8)	100.0	155 (0.9)	77 (0.8)	142 (3.1)	4 (0.4)	130 (2.8)	5 (0.5)	118 (1.8)	12 (0.5)	NA	NA
South Carolina	139 (1.5)	100.0	153 (1.6)	51 (1.9)	NA	NA	122 (1.6)	40 (1.9)	122 (4.1)	6 (0.6)	NA	NA
Tennessee	143 (1.8)	100.0	151 (1.7)	77 (1.5)	NA	NA	117 (3.1)	17 (1.5)	104 (6.2)	3 (0.5)	NA	NA
Texas	145 (1.8)	100.0	161 (1.2)	48 (1.9)	157 (3.6)	3 (0.5)	127 (2.4)	12 (1.3)	129 (2.7)	36 (2.1)	NA	NA
Utah	156 (0.8)	100.0	159 (0.7)	87 (1.0)	143 (3.2)	3 (0.4)	*	1 (0.2)	133 (2.9)	8 (0.7)	NA	NA
Vermont	157 (1.0)	100.0	159 (0.9)	90 (0.9)	NA	NA	*	1 (0.3)	136 (3.4)	4 (0.5)	NA	NA
Virginia	149 (1.6)	100.0	158 (1.4)	64 (2.0)	165 (3.2)	5 (0.6)	126 (2.3)	24 (1.9)	132 (4.2)	5 (0.6)	NA	NA
Washington	150 (1.3)	100.0	156 (1.1)	74 (1.9)	149 (3.3)	7 (0.9)	127 (4.2)	4 (0.7)	125 (3.5)	10 (1.1)	130 (4.3)	4 (0.6)
West Virginia	147 (0.9)	100.0	149 (0.9)	90 (0.7)	NA	NA	127 (3.2)	4 (0.5)	122 (4.3)	3 (0.3)	NA	NA
Wisconsin	160 (1.7)	100.0	165 (1.1)	83 (1.5)	NA	NA	115 (5.3)	6 (1.1)	141 (4.6)	6 (0.7)	NA	NA
Wyoming	158 (0.6)	100.0	161 (0.6)	84 (0.8)	NA	NA	*	1 (0.2)	140 (1.9)	11 (0.6)	138 (2.5)	4 (0.4)

* = sample size insufficient to permit reliable estimates; NA = not available

NOTES: Scale scores range from 0 to 300. Idaho, Illinois, Kansas, Nevada, New Hampshire, New Jersey, Ohio, Oklahoma, Pennsylvania, and South Dakota did not participate in the assessment. Standard errors are shown in parentheses. National results are based on the national assessment samples, not on aggregated state assessment program samples.

SOURCE: C. O'Sullivan, C. Reese, and J. Mazzeo, *NAEP 1996 Science Report Card for the Nation and the States* (Washington, DC: National Center for Education Statistics, 1997).

See figure 1-4.

Appendix table 1-5.

Overall mean and average percentage correct on grade 4 TIMSS science assessment, by country and content area: 1994-95

Country	Mean	All science content areas	Earth science	Life science	Physical science	Environmental issues/nature of science
All countries	**524**	59 0.1	57 0.1	64 0.1	57 0.2	51 (0.2)
Australia	562 (2.9)	66 (0.5)	61 (0.6)	72 (0.5)	63 (0.7)	63 (0.8)
Austria	565 (3.3)	66 (0.7)	62 (0.8)	72 (0.7)	64 (0.8)	54 (1.0)
Canada	549 (3.0)	64 (0.6)	62 (0.6)	68 (0.6)	61 (0.7)	56 (0.7)
Cyprus	475 (3.3)	51 (0.5)	48 (0.7)	55 (0.5)	50 (0.7)	42 (1.0)
Czech Republic	557 (3.1)	65 (0.5)	64 (0.6)	71 (0.5)	62 (0.7)	56 (0.9)
England and Wales	551 (3.3)	63 (0.6)	61 (0.6)	68 (0.6)	60 (0.8)	56 (1.0)
Greece	497 (4.1)	54 (0.8)	52 (0.9)	61 (0.9)	49 (0.9)	43 (1.2)
Hong Kong	533 (3.7)	62 (0.7)	61 (0.6)	68 (0.7)	60 (0.8)	50 (1.1)
Hungary	532 (3.4)	62 (0.6)	62 (0.7)	66 (0.6)	59 (0.8)	50 (0.9)
Iceland	505 (3.3)	55 (0.7)	55 (0.7)	60 (0.8)	52 (0.7)	47 (1.2)
Iran	416 (3.9)	40 (0.7)	38 (0.7)	44 (0.7)	40 (0.9)	26 (0.9)
Ireland	539 (3.3)	61 (0.6)	60 (0.8)	66 (0.6)	57 (0.7)	55 (0.9)
Israel	505 (3.6)	57 (0.8)	51 (0.8)	61 (0.9)	55 (0.9)	51 (1.3)
Japan	574 (1.8)	70 (0.3)	66 (0.4)	73 (0.3)	70 (0.4)	62 (0.6)
Kuwait	401 (3.1)	39 (0.5)	36 (0.6)	45 (0.6)	37 (0.5)	25 (0.7)
Latvia	512 (4.9)	56 (0.8)	57 (1.0)	60 (0.8)	54 (0.9)	46 (1.2)
Netherlands	557 (3.1)	67 (0.5)	61 (0.6)	73 (0.5)	65 (0.6)	61 (0.9)
New Zealand	531 (4.9)	60 (0.9)	57 (0.9)	66 (0.9)	57 (1.1)	54 (1.2)
Norway	530 (3.6)	60 (0.6)	60 (0.6)	67 (0.7)	55 (0.7)	53 (0.9)
Portugal	480 (4.0)	50 (0.7)	50 (0.8)	54 (0.8)	49 (0.9)	39 (1.0)
Scotland	536 (4.2)	60 (0.8)	58 (0.9)	65 (0.8)	57 (0.8)	53 (1.2)
Singapore	547 (5.0)	64 (0.8)	58 (0.8)	70 (0.8)	64 (0.8)	53 (1.1)
Slovenia	546 (3.3)	64 (0.7)	64 (0.7)	68 (0.7)	61 (0.8)	54 (0.8)
South Korea	597 (1.9)	74 (0.4)	72 (0.5)	76 (0.4)	75 (0.5)	70 (0.8)
Thailand	473 (4.9)	49 (0.9)	48 (0.9)	52 (0.8)	46 (1.0)	48 (1.4)
United States	565 (3.1)	66 (0.5)	64 (0.7)	71 (0.6)	60 (0.6)	65 (0.8)

TIMSS = Third International Mathematics and Science Study

NOTE: Standard errors are shown in parentheses.

SOURCE: M. Martin, I. Mullis, A. Beaton, E. Gonzalez, T. Smith, and D. Kelly, *Science Achievement in the Primary School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1997).

See figure 1-5.

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Appendix table 1-6.

Overall mean and average percentage correct on grade 8 TIMSS science assessment, by country and content area: 1994-95

Country	Mean	All science content areas	Earth science	Life science	Physics	Chemistry	Environ-mental issues/ nature of science
All countries	**516**	**56** (0.1)	55 (0.1)	59 (0.1)	55 (0.1)	51 (0.2)	53 (0.2)
Australia	545 (3.9)	**60** (0.7)	57 (0.8)	63 (0.8)	60 (0.7)	54 (0.9)	62 (1.0)
Austria	558 (3.7)	**61** (0.7)	62 (0.8)	65 (0.7)	62 (0.7)	58 (1.1)	55 (0.9)
Belgium (Flemish)	550 (4.2)	**60** (1.1)	62 (1.2)	64 (1.1)	61 (1.1)	51 (1.3)	58 (1.5)
Belgium (French)	471 (2.8)	**50** (0.7)	50 (0.9)	55 (0.9)	51 (0.7)	41 (0.8)	46 (1.0)
Bulgaria	565 (5.3)	**62** (1.0)	58 (1.2)	64 (1.0)	60 (1.0)	65 (1.7)	59 (1.5)
Canada	531 (2.6)	**59** (0.5)	58 (0.6)	62 (0.6)	59 (0.4)	52 (0.7)	61 (0.7)
Colombia	411 (4.1)	**39** (0.8)	37 (0.8)	44 (0.9)	37 (0.8)	32 (1.0)	40 (1.1)
Cyprus	463 (1.9)	**47** (0.4)	46 (0.6)	49 (0.5)	46 (0.4)	45 (0.6)	46 (0.8)
Czech Republic	574 (4.3)	**64** (0.8)	63 (1.2)	69 (0.8)	64 (0.7)	60 (1.2)	59 (1.1)
Denmark	478 (3.1)	**51** (0.6)	49 (0.7)	56 (0.7)	53 (0.7)	41 (0.8)	47 (1.0)
England and Wales	552 (3.3)	**61** (0.6)	59 (0.8)	64 (0.8)	62 (0.6)	55 (0.8)	65 (1.0)
France	498 (2.5)	**54** (0.6)	55 (0.8)	56 (0.8)	54 (0.5)	47 (0.9)	53 (0.9)
Germany	431 (4.8)	**58** (1.0)	57 (1.0)	63 (1.1)	57 (1.0)	54 (1.3)	51 (1.3)
Greece	497 (2.2)	**52** (0.5)	49 (0.6)	54 (0.6)	53 (0.5))	51 (0.5)	51 (1.0)
Hong Kong	522 (4.7)	**58** (1.0)	54 (1.0)	61 (1.0)	58 (0.9)	55 (1.0)	55 (1.3)
Hungary	554 (2.8)	**61** (0.6)	60 (0.8)	65 (0.7)	60 (0.6)	60 (0.8)	53 (0.8)
Iceland	494 (4.0)	**52** (0.9)	50 (1.2)	58 (1.0)	53 (0.9)	42 (0.8)	49 (1.0)
Iran	470 (2.4)	**47** (0.6)	45 (0.6)	49 (0.6)	48 (0.7)	52 (0.8)	39 (1.1)
Ireland	538 (4.5)	**58** (0.9)	61 (1.0)	60 (1.1)	56 (0.8)	54 (1.0)	60 (1.1)
Israel	524 (5.7)	**57** (1.1)	55 (1.1)	61 (1.1)	57 (1.1)	53 (1.5)	52 (1.6)
Japan	571 (1.6)	**65** (0.3)	61 (0.4)	71 (0.4)	67 (0.3)	61 (0.5)	60 (0.7)
Kuwait	430 (3.7)	**43** (0.9)	43 (1.0)	45 (1.1)	43 (0.7)	40 (1.5)	39 (1.3)
Latvia	485 (2.7)	**50** (0.6)	48 (0.8)	53 (0.7)	51 (0.7)	48 (0.8)	47 (1.0)
Lithuania	476 (3.4)	**49** (0.7)	46 (0.9)	52 (0.9)	51 (0.7)	48 (0.9)	40 (1.0)
Netherlands	560 (5.0)	**62** (1.0)	61 (1.4)	67 (1.4)	63 (0.9)	52 (0.9)	65 (1.6)
New Zealand	525 (4.4)	**58** (0.8)	56 (0.9)	60 (1.0)	58 (0.7)	53 (1.1)	59 (1.2)
Norway	527 (1.9)	**58** (0.4)	61 (0.6)	61 (0.5)	57 (0.4)	49 (0.6)	55 (0.8)
Portugal	480 (2.3)	**50** (0.6)	50 (0.7)	53 (0.6)	48 (0.5)	50 (0.9)	45 (0.8)
Romania	486 (4.7)	**50** (0.8)	49 (1.0)	55 (1.0)	49 (0.8)	46 (1.0)	42 (1.0)
Russian Federation	538 (4.0)	**58** (0.8)	58 (0.8)	62 (0.7)	57 (0.9)	57 (1.3)	50 (0.8)
Scotland	517 (5.1)	**55** (1.0)	52 (1.0)	57 (1.1)	57 (0.8)	51 (1.3)	57 (1.4)
Singapore	607 (5.5)	**70** (1.0)	65 (1.1)	72 (1.0)	69 (0.8)	69 (1.2)	74 (1.1)
Slovak Republic	544 (3.2)	**59** (0.6)	60 (0.7)	60 (0.6)	61 (0.6)	57 (0.8)	53 (0.9)
Slovenia	560 (2.5)	**62** (0.5)	64 (0.7)	65 (0.6)	61 (0.6)	56 (0.9)	59 (0.9)
South Africa	326 (6.6)	**27** (1.3)	26 (1.1)	27 (1.3)	27 (1.4)	26 (1.4)	26 (1.3)
South Korea	565 (1.9)	**66** (0.3)	63 (0.5)	70 (0.4)	65 (0.5)	63 (0.6)	64 (0.8)
Spain	517 (1.7)	**56** (0.4)	57 (0.5)	58 (0.5)	55 (0.4)	51 (0.7)	53 (0.6)
Sweden	535 (3.0)	**59** (0.6)	62 (0.7)	63 (0.7)	57 (0.5)	56 (0.7)	52 (0.8)
Switzerland	522 (2.5)	**56** (0.5)	58 (0.6)	59 (0.6)	58 (0.5)	50 (0.7)	51 (0.8)
Thailand	525 (3.7)	**57** (0.9)	56 (1.0)	66 (0.9)	54 (0.7)	43 (1.2)	62 (1.1)
United States	534 (4.7)	**58** (1.0)	58 (1.0)	63 (1.1)	56 (0.8)	53 (1.2)	61 (1.0)

TIMSS = Third International Mathematics and Science Study

NOTE: Standard errors are shown in parentheses.

SOURCE: A. Beaton, M. Martin, I. Mullis, E. Gonzalez, T. Smith, and D. Kelly, *Science Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1996).

See figure 1-6.

Science & Engineering Indicators – 1998

Appendix table 1-7.
Average percentage correct on TIMSS science assessment, by country, grade, and sex: 1994-95

Country	Grade 4		Grade 8	
	Boys	Girls	Boys	Girls
Australia	67 (0.6)[a]	65 (0.6)	61 (1.0)	59 (0.8)
Austria	67 (0.9)[a]	64 (0.7)	63 (0.8)	60 (0.8)
Belgium (Flemish)	NP	NP	62 (1.7)	59 (1.5)
Belgium (French)	NP	NP	52 (1.0)	49 (0.7)
Canada	64 (0.7)	63 (0.6)	60 (0.6)	58 (0.6)
Colombia	NP	NP	40 (1.4)	37 (0.8)
Cyprus	51 (0.7)	50 (0.6)	46 (0.4)	47 (0.6)
Czech Republic	67 (0.6)[a]	64 (0.7)	67 (0.8)[a]	61 (1.1)
Denmark	NP	NP	54 (0.6)[a]	48 (0.8)
England and Wales	64 (0.8)	63 (0.6)	63 (1.0)	60 (0.7)
France	NP	NP	55 (0.7)[a]	52 (0.7)
Germany	NP	NP	59 (1.2)	57 (1.0)
Greece	54 (1.0)	53 (1.0)	54 (0.6)	50 (0.6)
Hong Kong	63 (0.8)[a]	61 (0.7)	60 (1.1)	55 (1.1)
Hungary	63 (0.8)[a]	60 (0.7)	63 (0.7)	59 (0.7)
Iceland	56 (0.8)[a]	54 (0.8)	53 (1.2)	51 (0.9)
Iran	41 (1.0)	39 (0.9)	49 (0.8)	45 (0.8)
Ireland	61 (0.7)	61 (0.8)	60 (1.3)	57 (1.0)
Israel	58 (1.1)	57 (0.8)	61 (1.2)	54 (1.1)
Japan	70 (0.4)[a]	69 (0.4)	67 (0.5)	64 (0.4)
Latvia	55 (0.9)	57 (1.0)	52 (0.8)	48 (0.6)
Lithuania	NP	NP	51 (0.8)	47 (0.8)
Netherlands	70 (0.7)[a]	65 (0.7)	64 (1.2)	60 (1.1)
New Zealand	59 (1.2)	61 (0.9)	60 (1.0)	56 (1.0)
Norway	61 (0.8)	60 (0.7)	59 (0.6)	56 (0.4)
Portugal	50 (0.9)	50 (0.8)	52 (0.7)	48 (0.6)
Romania	NP	NP	51 (0.9)	49 (0.9)
Russian Federation	NP	NP	60 (0.9)	57 (0.7)
Scotland	61 (0.9)	60 (0.8)	57 (1.2)	53 (0.9)
Singapore	65 (0.9)	64 (1.0)	71 (1.2)	69 (1.1)
Slovak Republic	NP	NP	62 (0.6)	57 (0.7)
Slovenia	64 (0.7)	63 (0.8)	64 (0.6)	59 (0.7)
South Africa	NP	NP	28 (1.8)	25 (1.2)
South Korea	75 (0.5)[a]	73 (0.5)	67 (0.5)	64 (0.5)
Spain	NP	NP	58 (0.5)	54 (0.5)
Sweden	NP	NP	60 (0.6)	57 (0.6)
Switzerland	NP	NP	58 (0.6)	54 (0.5)
Thailand	49 (1.2)	49 (0.8)	57 (0.9)	58 (1.0)
United States	67 (0.6)[a]	65 (0.6)	59 (1.0)	57 (1.0)

NP = did not participate in grade 4 assessment; TIMSS = Third International Mathematics and Science Study.

NOTE: Standard errors are shown in parentheses.

[a] Difference between the sexes is statistically significant at the 0.05 level, adjusted for multiple comparisons.

SOURCES: A. Beaton, M. Martin, I. Mullis, E. Gonzalez, T. Smith, and D. Kelly, *Science Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1996); and M. Martin, I. Mullis, A. Beaton, E. Gonzalez, T. Smith, and D. Kelly, *Science Achievement in the Primary School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1997).

Science & Engineering Indicators – 1998

Appendix table 1-8.

Proportion of high school graduates earning credits in mathematics courses, by sex: 1982, 1987, 1990, and 1994

(Percentages)

Year of graduation and sex	Any mathematics	Basic math	General math	Applied math	Prealgebra	Algebra 1	Algebra 2	Geometry	Calculus	AP calculus	Advanced math—other
1982 graduates											
All	98.6 (0.1)	6.2 (0.5)	29.5 (1.1)	8.8 (0.4)	18.0 (0.8)	54.3 (0.9)	35.6 (0.8)	45.8 (0.8)	4.7 (0.4)	1.5 (0.3)	13.2 (0.8)
Male	98.9 (0.2)	7.4 (0.5)	32.3 (1.2)	10.1 (0.6)	17.5 (1.2)	52.7 (1.0)	35.9 (1.1)	45.4 (0.8)	5.2 (0.5)	1.6 (0.3)	14.8 (1.1)
Female	98.4 (0.2)	5.1 (0.7)	26.9 (1.2)	7.7 (0.6)	18.5 (0.8)	55.8 (1.2)	35.3 (0.9)	46.2 (1.2)	4.2 (0.4)	1.4 (0.3)	11.7 (0.7)
1987 graduates											
All	99.8 (0.1)	8.5 (0.7)	21.1 (1.3)	14.4 (1.0)	18.2 (1.2)	64.1 (1.1)	46.1 (1.6)	59.8 (1.0)	6.0 (0.4)	3.3 (0.4)	20.5 (1.1)
Male	99.8 (0.1)	9.2 (0.8)	23.1 (1.5)	15.3 (1.2)	17.9 (1.2)	62.3 (1.2)	44.8 (1.8)	58.9 (1.2)	7.4 (0.5)	3.8 (0.5)	22.2 (1.3)
Female	99.7 (0.1)	7.8 (0.8)	19.1 (1.1)	13.6 (1.0)	18.4 (1.2)	65.8 (1.1)	47.5 (1.7)	60.5 (1.0)	4.6 (0.4)	2.7 (0.4)	19.0 (1.2)
1990 graduates											
All	99.9 (0.0)	8.0 (0.7)	19.6 (1.5)	16.1 (1.2)	23.3 (1.4)	64.0 (1.6)	49.6 (1.3)	63.2 (1.4)	6.5 (0.5)	4.1 (0.4)	20.3 (1.2)
Male	99.9 (0.1)	8.9 (0.8)	21.6 (1.7)	17.0 (1.3)	23.5 (1.5)	61.4 (1.6)	47.7 (1.4)	62.1 (1.6)	7.5 (0.6)	5.0 (0.6)	21.4 (1.4)
Female	99.9 (0.1)	7.1 (0.7)	17.8 (1.4)	15.2 (1.2)	23.0 (1.4)	66.4 (1.8)	51.5 (1.5)	64.3 (1.4)	5.6 (0.4)	3.4 (0.4)	19.3 (1.1)
1994 graduates											
All	99.9 (0.0)	4.8 (0.5)	16.1 (1.0)	13.7 (1.0)	23.2 (1.0)	66.6 (1.4)	57.9 (1.5)	70.1 (1.4)	9.2 (0.5)	6.9 (0.5)	24.7 (0.8)
Male	99.9 (0.0)	5.7 (0.6)	18.2 (1.1)	14.8 (1.1)	24.4 (1.1)	64.7 (1.5)	54.5 (1.5)	67.9 (1.5)	9.4 (0.6)	7.1 (0.6)	24.0 (1.0)
Female	99.9 (0.0)	3.9 (0.4)	14.2 (1.1)	12.7 (0.9)	22.1 (1.1)	68.4 (1.5)	61.1 (1.6)	72.2 (1.4)	9.1 (0.6)	6.8 (0.5)	25.3 (1.0)

AP = advanced placement

NOTE: Standard errors are shown in parentheses.

SOURCE: National Center for Education Statistics, *The 1994 High School Transcript Study Tabulations: Comparative Data on Credits Earned and Demographics for 1994, 1990, 1987, and 1982 High School Graduates*, NCES 97-260 (Washington, DC: U.S. Department of Education, 1997).

Science & Engineering Indicators – 1998

See figure 1-7.

Appendix table 1-9.

Proportion of high school graduates earning credits in mathematics courses, by race/ethnicity: 1982, 1987, 1990, and 1994

(Percentage)

Year of graduation and race/ethnicity	Any mathematics	Basic math	General math	Applied math	Prealgebra	Algebra 1	Algebra 2	Geometry	Calculus	AP calculus	Advanced math–other
1982 graduates											
White	98.8 (0.2)	4.5 (0.4)	25.0 (1.1)	7.8 (0.6)	17.3 (0.9)	58.2 (1.0)	39.5 (0.9)	51.3 (1.0)	5. 5 (0.4)	1.8 (0.3)	4.2 (0.6)
Asian/Pacific Islander	100.0 (0.0)	4.9 (1.6)	17.1 (3.5)	9.6 (2.1)	15.5 (3.4)	55.5 (5.4)	55.8 (4.2)	64.9 (4.7)	12.8 (2.7)	5.5 (1.7)	5.6 (1.8)
Black	99.3 (0.3)	13.6 (2.1)	46.6 (3.1)	13.3 (1.5)	22.3 (2.1)	43.1 (1.8)	24.2 (2.0)	29.3 (1.8)	1.3 (0.4)	0.3 (0.1)	2.7 (0.5)
Hispanic	97.2 (0.5)	9.4 (1.2)	43.2 (2.1)	11.2 (1.2)	18.5 (1.3)	42.6 (1.5)	20.1 (1.4)	25.7 (1.4)	1.7 (0.3)	0.4 (0.1)	3.2 (0.4)
Native American	99.6 (0.5)	7.4 (4.2)	41.4 (5.2)	7.3 (3.3)	22.1 (5.8)	33.6 (6.5)	19.1 (4.5)	33.5 (7.2)	4.0 (2.2)	0.1 (0.1)	5.5 (3.0)
1987 graduates											
White	99.8 (0.1)	6:5 (0.6)	18.1 (1.3)	14.3 (1.3)	16.5 (1.3)	66.2 (1.3)	50.7 (1.6)	63.1 (1.2)	5.7 (0.4)	2.7 (0.3)	4.1 (1.2)
Asian/Pacific Islander	100.0 (0.0)	4.9 (1.3)	14.2 (3.1)	9.7 (1.3)	13.4 (2.8)	63.7 (2.5)	66.1 (4.7)	81.4 (2.5)	29.6 (4.1)	23.7 (4.7)	5.1 (1.4)
Black	99.8 (0.1)	17.1 (2.7)	37.9 (2.7)	18.4 (1.8)	23.2 (1.7)	54.6 (1.3)	30.0 (1.7)	42.3 (2.0)	2.2 (0.3)	1.4 (0.3)	2.1 (0.6)
Hispanic	99.9 (0.1)	21.0 (1.9)	29.3 (3.5)	15.6 (1.8)	27.9 (2.1)	53.6 (1.8)	27.6 (2.0)	39.7 (1.7)	3.6 (0.7)	2.6 (0.6)	2.1 (0.7)
Native American	99.3 (0.8)	7.2 (1.6)	37.2 (4.7)	29.9 (4.4)	40.0 (7.6)	61.4 (2.2)	23.8 (2.6)	43.5 (4.0)	0.4 (0.4)	0.4 (0.4)	4.7 (0.9)
1990 graduates											
White	99.9 (0.1)	5.8 (0.6)	17.5 (1.8)	15.0 (1.1)	21.8 (1.6)	64.1 (1.9)	53.1 (1.6)	65.5 (1.5)	6.9 (0.5)	4.2 (0.5)	5.0 (1.4)
Asian/Pacific Islander	99.9 (0.2)	8.4 (2.6)	14.7 (1.8)	13.0 (3.5)	16.4 (2.7)	63.3 (3.1)	60.9 (5.0)	70.7 (2.8)	18.5 (3.3)	15.6 (2.8)	2.6 (1.1)
Black	99.9 (0.1)	14.3 (1.9)	28.4 (2.3)	21.3 (2.7)	26.7 (2.3)	64.7 (2.4)	40.6 (2.8)	55.8 (2.6)	2.7 (0.5)	1.2 (0.3)	1.9 (1.0)
Hispanic	99.8 (0.1)	15.3 (2.7)	28.6 (3.0)	19.1 (3.7)	35.3 (3.2)	64.3 (2.7)	35.1 (2.6)	53.2 (2.8)	3.8 (0.7)	3.0 (0.6)	1.6 (0.7)
Native American	100.0 (0.0)	11.1 (3.0)	28.9 (7.0)	20.7 (4.6)	33.8 (6.5)	60.7 (8.5)	47.1 (5.4)	54.8 (3.1)	4.1 (2.7)	2.9 (2.5)	2.9 (1.2)
1994 graduates											
White	99.9 (0.0)	3.7 (0.5)	14.4 (1.2)	13.2 (1.2)	22.2 (1.1)	67.7 (1.6)	61.6 (1.6)	72.4 (1.6)	9.5 (0.6)	7.3 (0.6)	4.6 (1.0)
Asian/Pacific Islander	100.0 (0.0)	4.0 (0.9)	17.5 (2.8)	11.4 (3.1)	18.0 (3.5)	63.0 (2.1)	66.2 (5.0)	75.7 (3.8)	23.6 (3.2)	21.1 (2.9)	5.5 (1.6)
Black	100.0 (0.0)	7.3 (1.3)	27.0 (2.9)	17.5 (2.0)	27.3 (2.5)	65.0 (2.8)	44.0 (2.4)	58.2 (3.1)	3.8 (0.6)	2.0 (0.4)	1.5 (0.3)
Hispanic	99.9 (0.1)	8.4 (1.1)	16.2 (1.8)	16.4 (1.7)	34.0 (2.9)	69.9 (1.3)	49.6 (1.8)	68.8 (1.7)	6.0 (0.5)	4.6 (0.5)	3.0 (0.7)
Native American	100.0 (0.0)	5.4 (1.5)	19.1 (3.4)	13.8 (2.9)	39.5 (8.2)	68.9 (4.9)	42.2 (6.8)	60.0 (4.4)	3.8 (1.2)	2.2 (1.4)	2.9 (1.6)

AP = advanced placement

NOTE: Standard errors are shown in parentheses.

SOURCE: National Center for Education Statistics, *The 1994 High School Transcript Study Tabulations: Comparative Data on Credits Earned and Demographics for 1994, 1990, 1987, and 1982 High School Graduates*, NCES 97-260 (Washington, DC: U.S. Department of Education, 1997).

Science & Engineering Indicators – 1998

See figure 1-8.

Appendix table 1-10.

Student achievement levels on the National Assessment of Educational Progress in mathematics, by grade, sex, race/ethnicity, and region: 1990, 1992, and 1996

Student grade, sex race/ethnicity, and region	Percentage at or above level 2						Percentage at or above level 3					
	1990		1992		1996		1990		1992		1996	
Grade 4												
All students	50	(1.4)	59	(1.0)	64[a,b]	(1.2)	13	(1.2)	18	(1.0)	21[a,b]	(0.9)
Male	51	(1.7)	60	(1.1)	65	(1.6)	13	(1.5)	19	(1.1)	24	(1.1)
Female	49	(1.9)	57	(1.6)	63	(1.6)	12	(1.3)	16	(1.3)	19	(1.1)
White	59	(1.7)	70	(1.2)	76	(1.4)	16	(1.6)	23	(1.4)	28	(1.2)
Asian/Pacific Islander	65	(5.4)	75	(3.2)	73	(5.0)	23	(5.6)	30	(4.5)	26	(5.3)
Black	19	(2.4)	23	(1.8)	32	(3.2)	1	(0.6)	3	(0.7)	5	(1.4)
Hispanic	31	(2.6)	35	(2.1)	41	(2.4)	5	(1.1)	5	(1.1)	8	(1.0)
Native American	44	(8.3)	43	(4.8)	52	(2.7)	5	(2.6)	10	(3.6)	8	(2.5)
Northeast	51	(4.2)	63	(2.7)	70	(2.9)	14	(3.4)	23	(2.5)	26	(1.6)
Southeast	40	(2.9)	48	(2.2)	55	(2.9)	8	(1.6)	11	(1.2)	16	(2.4)
Central	55	(2.7)	66	(2.8)	75	(2.6)	14	(1.6)	21	(1.7)	27	(2.1)
West	54	(3.2)	59	(2.1)	58	(2.8)	15	(2.3)	17	(2.2)	18	(1.7)
Grade 8												
All students	52	(1.4)	58	(1.1)	62[a,b]	(1.1)	15	(1.1)	21	(1.0)	24[a]	(1.1)
Male	52	(1.9)	57	(1.4)	62	(1.7)	17	(1.5)	21	(1.3)	25	(1.5)
Female	52	(1.5)	58	(1.4)	63	(1.3)	14	(1.1)	21	(1.2)	23	(1.2)
White	61	(1.6)	69	(1.3)	74	(1.3)	19	(1.3)	27	(1.2)	31	(1.4)
Asian/Pacific Islander	71	(5.8)	76	(4.6)	–	–	32	(5.8)	40	(6.8)	–	–
Black	22	(2.4)	21	(2.0)	28	(2.8)	5	(1.0)	2	(0.7)	4	(0.9)
Hispanic	32	(3.1)	34	(1.9)	39	(2.5)	5	(1.3)	6	(0.8)	9	(1.6)
Native American	33	(10.2)	39	(5.8)	51	(6.2)	6	–	7	(3.1)	13	(5.0)
Northeast	59	(4.0)	57	(3.5)	67	(3.1)	20	(2.7)	23	(2.5)	27	(3.7)
Southeast	43	(2.6)	50	(1.8)	56	(3.2)	12	(2.1)	15	(1.2)	18	(1.8)
Central	57	(2.5)	66	(2.7)	69	(3.4)	15	(1.3)	25	(2.4)	29	(2.5)
West	50	(2.6)	58	(2.5)	59	(2.2)	15	(2.1)	21	(1.9)	22	(1.9)
Grade 12												
All students	58	(1.6)	64	(1.1)	69[a,b]	(1.3)	12	(0.9)	15	(0.8)	16[a]	(1.1)
Male	60	(1.8)	65	(1.3)	70	(1.4)	15	(1.4)	17	(1.0)	18	(1.3)
Female	56	(1.8)	63	(1.3)	69	(1.5)	9	(0.9)	13	(1.0)	14	(1.2)
White	66	(1.8)	72	(1.3)	79	(1.3)	14	(1.1)	18	(0.9)	20	(1.3)
Asian/Pacific Islander	75	(5.8)	81	(4.3)	81	(4.3)	23	(7.1)	30	(5.6)	33	(6.3)
Black	27	(2.7)	34	(2.6)	38	(3.3)	2	(0.8)	2	(0.5)	4	(1.0)
Hispanic	36	(3.9)	45	(2.0)	50	(3.6)	4	(1.1)	6	(0.9)	6	(1.1)
Native American	–	–	–	–	34	(16.0)	–	–	–	–	3	†
Northeast	64	(3.1)	66	(2.0)	72	(2.9)	16	(1.9)	18	(1.5)	21	(2.1)
Southeast	47	(3.9)	55	(2.1)	58	(2.6)	6	(0.8)	10	(1.1)	11	(1.5)
Central	62	(3.5)	70	(2.6)	77	(3.6)	13	(1.7)	17	(1.4)	20	(2.8)
West	57	(3.2)	64	(1.7)	69	(2.4)	12	(2.5)	14	(1.6)	14	(1.7)

– = results omitted by source; † = standard error estimate cannot be accurately determined

NOTES: At grade 4, level 2 performance corresponds to average scale scores of 214-248 and level 3 to scores of 249-281. At grade 8, level 2 corresponds to scores of 262-298 and level 3 to scores of 299-332. At grade 12, level 2 corresponds to scores of 288-335 and level 3 to scores of 336-366. Significance levels are reported here only by grade. Race/ethnicity data are based only on those students who indicated their race/ethnicity. Standard errors are shown in parentheses.

[a] Statistically significant difference from 1990.

[b] Statistically significant difference from 1992.

SOURCE: C. Reese, K. Miller, J. Mazzeo, and J. Dossey, *NAEP 1996 Mathematics Report Card for the Nation and the States* (Washington, DC: National Center for Education Statistics, 1997).

See figure 1-10.

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Appendix table 1-11.

Grade 8 student achievement levels on the National Assessment of Educational Progress in mathematics, by state and race/ethnicity: 1990, 1992, and 1996

	Percentage of all students:				Percentage of white students:				Percentage of black students:				Percentage of Hispanic students:			
State	At or above level 3		At or above level 2		At or above level 3		At or above level 2		At or above level 3		At or above level 2		At or above level 3		At or above level 2	
								1990								
Nation	19	1.2	57	1.4	24	1.6	67	1.6	6	1.3	27	3.1	6	1.6	36	3.1
Alabama	12	0.8	47	1.6	16	1.1	59	1.6	3	0.7	23	2.3	4	1.8	20	4.4
Arizona	16	1.1	55	1.8	23	1.5	69	1.6	6	3.2	35	5.3	5	1.0	34	2.4
Arkansas	12	1.0	51	1.3	16	1.2	63	1.6	1	0.6	19	1.1	4	2.8	21	6.3
California	16	1.3	51	1.6	24	2.1	68	1.9	3	1.8	23	3.1	4	0.9	30	2.2
Colorado	22	1.0	64	1.1	27	1.4	73	1.2	2	1.7	28	6.8	6	1.5	40	2.4
Connecticut	26	1.1	66	1.3	31	1.3	75	1.2	5	2.0	33	3.6	5	2.2	30	3.3
Delaware	19	0.9	55	1.3	24	1.2	63	2.0	6	1.2	34	2.2	8	3.5	35	6.7
Florida	15	0.1	49	1.4	19	1.5	61	1.9	3	0.9	22	2.0	10	1.5	37	3.1
Georgia	17	1.3	53	1.5	25	1.8	68	1.6	5	0.8	30	2.0	5	2.2	26	3.7
Hawaii	14	0.8	45	1.0	20	2.7	58	2.6	•		•		5	1.6	23	3.5
Idaho	23	1.4	70	1.2	25	1.6	73	1.3	•		•		7	2.7	42	4.9
Indiana	21	1.2	63	1.6	23	1.2	68	1.5	3	1.4	31	4.5	10	2.8	33	4.7
Iowa	30	1.5	76	1.1	32	1.7	78	1.1	•		•		11	3.6	48	5.7
Kentucky	14	0.9	51	1.8	15	1.1	54	2.0	3	1.5	31	3.5	1	1.2	18	4.6
Louisiana	8	1.0	39	1.7	12	1.6	54	2.0	2	0.5	18	1.9	3	1.6	19	4.1
Maryland	20	1.2	56	1.7	27	1.6	70	1.9	5	1.1	29	2.6	8	1.8	30	3.4
Michigan	20	1.4	60	1.4	24	1.5	69	1.4	1	0.9	18	1.8	6	2.7	35	4.2
Minnesota	29	1.2	74	1.3	30	1.3	77	1.2	10	3.4	30	6.0	6	2.6	33	7.4
Nebraska	30	1.4	74	1.1	33	1.5	79	1.2	4	3.4	25	5.2	6	2.9	49	6.8
New Hampshire	25	1.2	71	1.6	26	1.2	72	1.6	•		•		11	4.6	48	7.4
New Jersey	25	1.3	65	1.6	31	1.9	77	1.7	6	1.4	31	2.6	7	1.7	33	2.7
New Mexico	13	0.9	51	1.3	23	2.0	72	1.7	•		•		5	0.8	38	1.8
New York	19	1.0	57	1.7	26	1.5	72	1.3	4	1.1	26	4.1	6	1.9	30	4.3
North Carolina	11	0.8	44	1.4	16	1.2	58	1.9	3	0.9	23	1.9	1	1.0	12	3.9
North Dakota	34	2.0	81	1.6	36	2.0	85	1.3	•		•		8	4.5	42	7.5
Ohio	19	1.2	60	1.4	21	1.2	66	1.4	2	1.2	22	3.2	6	3.0	28	7.2
Oklahoma	17	1.3	59	1.6	20	1.5	66	1.8	2	1.1	25	3.0	6	2.5	40	5.8
Pennsylvania	21	1.5	63	2.0	25	1.3	70	1.3	3	2.5	29	4.6	4	2.0	20	4.3
Rhode Island	18	1.0	55	0.9	21	1.2	61	1.0	2	1.4	20	4.2	2	0.9	21	3.7
Texas	16	1.0	52	1.7	26	1.8	71	1.7	3	1.0	23	2.6	6	0.9	36	2.1
Virginia	21	1.6	58	1.6	25	2.0	67	1.7	5	1.1	32	2.5	10	3.7	34	5.0
West Virginia	12	0.9	49	1.2	13	0.9	51	1.2	4	3.3	23	6.1	5	2.7	24	5.3
Wisconsin	29	1.5	72	1.7	32	1.6	79	1.5	4	2.1	24	6.1	8	2.7	42	5.7
Wyoming	24	1.0	71	1.3	26	1.1	74	1.3	•		•		10	2.7	50	3.5

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Appendix table 1-11.

Grade 8 student achievement levels on the National Assessment of Educational Progress in mathematics, by state and race/ethnicity: 1990, 1992, and 1996

	Percentage of all students:				Percentage of white students:				Percentage of black students:				Percentage of Hispanic students:			
State	At or above level 3		At or above level 2		At or above level 3		At or above level 2		At or above level 3		At or above level 2		At or above level 3		At or above level 2	
								1992								
Nation	23	1.1	61	1.2	30	1.4	73	1.4	3	0.8	26	2.2	7	0.9	37	2.1
Alabama	12	1.1	44	2.0	19	1.5	59	2.1	1	0.4	19	2.1	1	1.4	15	4.6
Arizona	19	1.4	61	1.8	26	1.8	74	1.7	6	2.9	42	7.8	7	1.4	40	3.6
Arkansas	13	1.0	50	1.7	17	1.1	61	1.8	2	0.9	18	2.2	5	1.6	23	4.7
California	20	1.4	55	2.0	30	2.2	73	2.1	3	1.4	26	5.0	6	1.1	34	2.2
Colorado	26	1.3	69	1.3	31	1.5	77	1.2	6	2.8	33	5.8	10	1.3	48	2.6
Connecticut	30	1.1	69	1.4	38	1.3	81	1.2	5	1.3	32	4.8	6	1.4	32	3.1
Delaware	18	1.1	57	1.2	25	1.5	69	1.5	4	1.2	31	2.7	5	2.8	33	3.7
Florida	18	1.3	55	1.9	26	1.8	70	1.8	4	0.9	27	2.7	7	1.4	40	4.3
Georgia	16	1.0	53	1.5	23	1.6	69	1.8	4	0.9	29	2.1	5	2.7	27	8.6
Hawaii	16	0.8	51	1.2	22	2.4	62	2.4	*		*		5	1.4	34	3.5
Idaho	27	1.2	73	1.1	29	1.2	76	1.1	*		*		9	2.2	46	4.5
Indiana	24	1.3	66	1.5	27	1.5	70	1.6	5	1.9	34	3.9	11	3.8	46	8.0
Iowa	37	1.4	81	1.2	39	1.4	83	1.3	*		*		15	3.4	53	5.7
Kentucky	17	1.1	57	1.3	18	1.2	61	1.3	5	1.7	30	3.9	5	3.0	26	6.2
Louisiana	10	1.2	42	2.0	16	1.7	59	2.3	2	0.6	22	2.2	2	1.5	21	3.8
Maine	31	1.9	77	1.3	32	2.0	79	1.2	*		*		*		*	
Maryland	24	1.3	59	1.5	34	1.8	74	1.7	4	1.4	30	2.5	6	2.1	33	4.1
Massachusetts	28	1.4	68	1.5	31	1.6	74	1.6	8	2.7	35	5.3	5	1.8	30	4.5
Michigan	23	1.7	63	1.6	29	2.0	75	1.6	2	0.7	22	2.8	11	3.5	44	5.7
Minnesota	37	1.2	79	1.2	39	1.2	81	1.2	*		*		8	2.8	48	6.7
Mississippi	8	0.8	38	1.5	16	1.4	59	1.9	1	0.5	19	1.4	1	0.9	12	3.2
Missouri	24	1.3	68	1.6	27	1.4	75	1.4	4	1.3	30	3.1	11	3.6	38	6.4
Nebraska	32	1.9	75	1.2	35	2.0	81	1.2	2	1.3	25	8.1	12	3.4	47	5.9
New Hampshire	30	1.5	77	1.0	31	1.4	78	1.0	*		*		13	5.6	56	7.1
New Jersey	28	1.4	67	1.8	36	2.0	82	1.3	5	1.4	32	3.8	7	1.9	41	4.3
New Mexico	14	1.0	54	1.4	23	1.8	72	1.6	*		*		6	0.8	40	1.8
New York	24	1.6	62	2.3	32	2.0	78	1.4	4	1.6	25	5.2	8	2.1	38	4.9
North Carolina	15	1.0	53	1.5	20	1.2	63	1.6	4	0.8	29	2.8	7	4.2	28	6.1
North Dakota	36	1.7	82	1.3	37	1.7	84	1.3	*		*		*		*	
Ohio	22	1.4	64	2.0	26	1.6	72	2.0	4	1.0	24	3.0	7	2.6	38	5.6
Oklahoma	21	1.2	65	2.0	24	1.2	72	2.2	3	1.1	28	5.2	11	3.6	46	5.4
Pennsylvania	26	1.5	67	1.7	29	1.4	73	1.4	6	4.1	28	5.0	8	3.9	38	5.6
Rhode Island	20	1.3	62	1.2	23	1.5	69	1.4	4	3.3	32	4.9	3	1.4	22	4.3
South Carolina	18	1.1	53	1.2	27	1.7	70	1.2	4	0.9	30	1.6	2	1.2	21	4.0
Tennessee	15	1.2	53	1.8	18	1.4	62	1.5	3	1.0	21	3.1	2	1.8	23	5.8
Texas	21	1.4	58	1.5	32	2.2	76	1.8	7	1.5	33	3.0	8	1.0	40	1.9
Utah	27	1.1	72	1.3	29	1.2	75	1.3	*		*		9	2.1	47	3.9
Virginia	23	1.2	62	1.6	28	1.4	71	1.6	6	1.3	35	3.3	13	4.1	50	4.4
West Virginia	13	0.9	53	1.5	13	1.0	55	1.5	5	2.4	31	6.5	2	1.5	19	6.3
Wisconsin	32	1.4	76	1.9	36	1.4	81	1.5	10	5.2	38	9.2	6	2.2	43	6.7
Wyoming	26	1.0	73	1.3	28	1.1	77	1.1	*		*		11	2.5	53	4.1

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Appendix table 1-11.

Grade 8 student achievement levels on the National Assessment of Educational Progress in mathematics, by state and race/ethnicity: 1990, 1992, and 1996

	Percentage of all students:		Percentage of white students:		Percentage of black students:		Percentage of Hispanic students:	
State	At or above level 3	At or above level 2	At or above level 3	At or above level 2	At or above level 3	At or above level 2	At or above level 3	At or above level 2
				1996				
Nation	23 (1.1)	61 (1.5)	30 (1.5)	73 (1.5)	4 (0.9)	27 (2.9)	8 (1.6)	37 (2.5)
Alabama	12 (1.8)	45 (2.6)	18 (2.7)	63 (3.2)	1 (0.5)	17 (2.0)	6 (2.6)	23 (5.0)
Alaska	30 (1.6)	68 (2.3)	37 (1.9)	77 (2.2)	*	*	13 (4.9)	44 (8.1)
Arizona	18 (1.2)	57 (1.9)	25 (1.7)	72 (1.8)	5 (2.7)	34 (6.2)	6 (1.1)	35 (2.6)
Arkansas	13 (1.0)	52 (1.8)	17 (1.3)	62 (1.8)	2 (0.9)	17 (2.9)	*	*
California	17 (1.5)	51 (2.1)	28 (2.3)	71 (2.0)	2 †	25 (4.4)	5 (0.8)	32 (2.4)
Colorado	25 (1.3)	67 (1.3)	31 (1.4)	76 (1.2)	8 (3.6)	40 (4.8)	10 (1.5)	43 (3.1)
Connecticut	31 (1.5)	70 (1.4)	37 (1.6)	80 (1.4)	4 (1.5)	29 (3.8)	8 (1.9)	37 (2.5)
Delaware	19 (1.0)	55 (1.3)	24 (1.4)	66 (1.8)	4 (1.2)	27 (4.2)	8 (3.2)	36 (5.5)
Florida	17 (1.3)	54 (2.1)	26 (1.9)	72 (2.3)	3 (1.1)	21 (2.2)	8 (1.6)	39 (2.6)
Georgia	16 (1.8)	51 (2.0)	24 (2.6)	68 (2.1)	3 (0.8)	24 (1.7)	10 (4.2)	36 (6.6)
Hawaii	16 (0.9)	51 (1.5)	22 (3.5)	62 (3.3)	*	*	7 (1.6)	33 (3.1)
Indiana	24 (1.7)	68 (2.0)	27 (1.8)	74 (1.9)	2 (1.0)	31 (4.4)	10 (3.1)	44 (7.6)
Iowa	31 (1.8)	78 (1.4)	33 (1.8)	79 (1.4)	11 (4.1)	38 (6.9)	12 (5.0)	57 (6.3)
Kentucky	16 (1.2)	56 (1.6)	17 (1.3)	60 (1.6)	2 †	31 (4.0)	*	*
Louisiana	7 (1.1)	38 (2.0)	12 (1.6)	56 (1.8)	2 (0.5)	17 (2.0)	2 †	24 (4.6)
Maine	31 (1.7)	77 (1.5)	32 (1.7)	78 (1.6)	*	*	*	*
Maryland	24 (2.3)	57 (2.2)	34 (2.8)	75 (1.9)	4 (1.0)	26 (2.2)	14 (3.7)	36 (5.2)
Massachusetts	28 (1.8)	68 (2.3)	32 (2.1)	75 (2.0)	8 (3.3)	35 (5.4)	5 (2.2)	26 (5.5)
Michigan	28 (1.8)	67 (2.1)	34 (1.9)	77 (1.7)	5 (2.0)	29 (4.6)	12 (4.6)	37 (5.2)
Minnesota	34 (1.8)	75 (1.5)	37 (1.9)	79 (1.4)	6 (3.5)	33 (7.1)	19 (6.4)	49 (7.7)
Mississippi	7 (0.8)	36 (1.3)	13 (1.6)	56 (1.9)	1 (0.3)	16 (1.3)	3 (1.7)	11 (2.9)
Missouri	22 (1.4)	64 (2.0)	25 (1.6)	70 (2.1)	4 (1.7)	26 (4.7)	10 (4.3)	48 (8.2)
Montana	32 (1.5)	75 (1.7)	36 (1.5)	79 (1.5)	*	*	12 (4.1)	52 (6.5)
Nebraska	31 (1.5)	76 (1.1)	34 (1.6)	80 (1.1)	7 (3.3)	40 (4.5)	7 (2.8)	44 (5.6)
New Mexico	14 (1.1)	51 (1.6)	28 (1.8)	72 (2.0)	*	*	6 (1.2)	38 (1.9)
New York	22 (1.5)	61 (2.0)	31 (1.8)	77 (1.8)	4 (1.8)	32 (4.0)	6 (1.4)	30 (3.6)
North Carolina	20 (1.3)	56 (1.8)	28 (1.6)	69 (1.8)	5 (1.0)	31 (2.5)	7 (2.8)	41 (5.6)
North Dakota	33 (1.5)	77 (1.2)	35 (1.5)	80 (1.1)	*	*	13 (4.9)	55 (8.5)
Oregon	26 (1.6)	67 (1.7)	29 (1.7)	70 (1.6)	*	*	13 (3.7)	46 (5.3)
Rhode Island	20 (1.3)	60 (1.6)	24 (1.5)	67 (1.6)	7 (3.6)	31 (5.0)	4 (1.4)	27 (5.8)
South Carolina	14 (1.2)	48 (1.7)	22 (2.1)	65 (2.3)	3 (0.6)	28 (1.9)	4 (2.9)	26 (5.6)
Tennessee	15 (1.3)	53 (1.8)	18 (1.5)	62 (2.1)	3 (1.2)	19 (2.9)	6 (2.7)	32 (8.0)
Texas	21 (1.5)	59 (1.8)	33 (1.8)	78 (1.7)	5 (1.7)	31 (4.3)	8 (1.4)	42 (2.6)
Utah	24 (1.3)	70 (1.5)	27 (1.3)	73 (1.3)	*	*	6 (1.8)	45 (4.4)
Vermont	27 (1.4)	72 (1.7)	29 (1.4)	74 (1.6)	*	*	*	*
Virginia	21 (1.2)	58 (2.0)	28 (1.4)	71 (1.8)	4 (0.8)	26 (3.3)	9 (3.4)	44 (7.3)
Washington	26 (1.2)	67 (1.6)	30 (1.4)	74 (1.5)	5 (2.7)	27 (5.4)	10 (2.8)	36 (4.5)
West Virginia	14 (0.9)	54 (1.6)	15 (0.9)	56 (1.7)	2 †	29 (6.3)	7 (4.2)	30 (6.6)
Wisconsin	32 (2.0)	75 (2.0)	36 (2.0)	82 (1.7)	2 †	19 (4.6)	10 (2.9)	45 (6.1)
Wyoming	22 (1.0)	68 (1.2)	24 (1.0)	72 (1.2)	*	*	8 (1.6)	45 (5.0)

* = sample size insufficient to permit reliable estimates; † = standard error estimate cannot be accurately determined

NOTES: At grade 8, level 2 corresponds to scores of 262-298 and level 3 to scores of 299-332. At grade 12, level 2 corresponds to scores of 288-335 and level 3 to scores of 336-366. Idaho, Illinois, Kansas, Nevada, New Hampshire, New Jersey, Ohio, Oklahoma, Pennsylvania, and South Dakota did not participate in the assessment. Standard errors are shown in parentheses. National results are based on the national assessment samples, not on aggregated state assessment program samples.

SOURCE: C. Reese, K. Miller, J. Mazzeo, and J. Dossey, *NAEP 1996 Mathematics Report Card for the Nation and the States* (Washington, DC: National Center for Education Statistics, 1997).

See figure 1-11. *Science & Engineering Indicators – 1998*

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Appendix table 1-12.

Overall mean and average percentage correct on grade 4 TIMSS mathematics assessment, by country and content area: 1994-95

Country	Mean	All mathematics content areas	Whole numbers	Fractions and proportionality	Measurement, estimation, and probability	Data representation, analysis, and probability	Geometry	Patterns, relations, and functions
All countries	529 (5.1)	59 (0.2)	67 (0.2)	49 (0.2)	56 (0.2)	62 (0.2)	64 (0.2)	60 (0.2)
Australia	546 (3.1)	63 (0.6)	67 (0.6)	51 (0.7)	60 (0.7)	67 (0.8)	74 (0.7)	64 (0.9)
Austria	559 (3.1)	65 (0.7)	74 (0.8)	51 (0.8)	69 (0.8)	66 (1.1)	67 (0.8)	64 (1.1)
Canada	532 (3.3)	60 (1.0)	68 (0.9)	48 (1.0)	54 (1.1)	68 (1.4)	72 (1.4)	62 (1.5)
Cyprus	502 (3.1)	54 (0.6)	65 (0.7)	48 (0.7)	48 (0.8)	52 (0.9)	53 (0.9)	55 (1.1)
Czech Republic	567 (3.3)	66 (0.6)	75 (0.6)	53 (0.8)	68 (0.7)	67 (0.9)	71 (0.7)	67 (0.9)
England and Wales	513 (3.2)	57 (0.7)	58 (0.7)	45 (0.8)	52 (0.7)	64 (0.9)	74 (0.8)	55 (1.0)
Greece	592 (4.4)	51 (0.9)	62 (1.0)	42 (1.1)	48 (1.0)	50 (1.2)	53 (1.2)	47 (1.2)
Hong Kong	587 (4.3)	73 (0.9)	79 (0.9)	66 (1.0)	69 (0.9)	76 (1.0)	74 (0.8)	73 (1.2)
Hungary	548 (3.7)	64 (0.8)	76 (0.7)	49 (0.9)	64 (0.9)	60 (1.0)	66 (0.8)	69 (1.1)
Iceland	474 (2.7)	50 (0.8)	56 (0.9)	36 (1.0)	44 (0.9)	58 (1.2)	63 (1.0)	48 (1.4)
Iran	429 (4.0)	38 (0.9)	51 (1.2)	32 (1.0)	36 (0.9)	23 (0.9)	42 (0.9)	40 (1.4)
Ireland	550 (3.4)	63 (0.8)	70 (0.8)	58 (1.0)	56 (0.9)	69 (0.9)	66 (0.8)	64 (1.0)
Israel	531 (3.5)	59 (1.0)	71 (1.0)	48 (1.1)	54 (1.0)	64 (1.2)	62 (1.0)	60 (1.5)
Japan	597 (2.1)	74 (0.4)	82 (0.4)	65 (0.6)	72 (0.5)	79 (0.5)	72 (0.6)	76 (0.6)
Kuwait	400 (2.8)	32 (0.5)	36 (0.5)	25 (0.5)	35 (0.6)	26 (0.6)	36 (0.6)	33 (1.0)
Latvia	525 (4.8)	59 (1.0)	68 (0.9)	44 (1.3)	60 (1.0)	54 (1.3)	67 (1.0)	65 (1.2)
Netherlands	577 (3.4)	69 (0.7)	75 (0.8)	60 (0.9)	70 (0.8)	75 (0.9)	71 (0.8)	65 (1.1)
New Zealand	499 (4.3)	53 (1.0)	57 (1.0)	41 (1.1)	49 (1.1)	61 (1.3)	66 (1.1)	52 (1.2)
Norway	502 (3.0)	53 (0.7)	61 (0.8)	38 (0.7)	56 (0.7)	59 (0.9)	58 (0.9)	50 (1.2)
Portugal	475 (3.5)	48 (0.7)	57 (0.8)	38 (0.7)	49 (0.8)	43 (1.1)	52 (1.0)	47 (1.1)
Scotland	520 (3.9)	58 (0.8)	61 (0.8)	46 (1.0)	53 (0.9)	66 (1.0)	72 (0.8)	57 (1.0)
Singapore	625 (5.3)	76 (0.8)	83 (0.7)	74 (1.0)	67 (1.0)	81 (0.8)	72 (0.8)	76 (0.9)
Slovenia	552 (3.2)	64 (0.6)	74 (0.6)	50 (0.9)	64 (0.9)	64 (1.0)	72 (0.8)	68 (0.8)
South Korea	611 (2.1)	76 (0.4)	88 (0.3)	65 (0.5)	72 (0.5)	80 (0.6)	72 (0.6)	83 (0.7)
Thailand	490 (4.7)	50 (1.1)	58 (1.3)	44 (1.0)	44 (1.0)	56 (1.5)	53 (1.2)	50 (1.3)
United States	545 (3.0)	63 (0.6)	71 (0.7)	51 (0.8)	53 (0.6)	73 (0.9)	71 (0.7)	66 (0.9)

NOTE: Standard errors are shown in parentheses.

SOURCE: I. Mullis, M. Martin, A. Beaton, E. Gonzalez, D. Kelly, and T. Smith, *Mathematics Achievement in the Primary School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1997).

See figure 1-12.

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Appendix table 1-13.

Overall mean and average percentage correct on grade 8 TIMSS mathematics assessment, by country and content area: 1994-95

Country	Mean	All mathematics content areas	Fractions and number sense	Geometry	Algebra	Data representation, analysis, and probability	Measurement	Proportionality
All countries	513 NR	55 (0.1)	58 (0.1)	56 (0.1)	52 (0.2)	62 (0.1)	51 (0.1)	45 (0.2)
Australia	530 (4.0)	58 (0.9)	61 (0.9)	57 (1.0)	55 (1.0)	67 (0.8)	54 (1.0)	47 (0.9)
Austria	539 (3.0)	62 (0.8)	66 (0.8)	57 (1.0)	59 (0.8)	68 (0.8)	62 (1.0)	49 (0.9)
Belgium (Flemish)	565 (5.7)	66 (1.4)	71 (1.2)	64 (1.5)	63 (1.7)	73 (1.3)	60 (1.3)	53 (1.8)
Belgium (French)	526 (3.4)	59 (0.9)	62 (1.0)	58 (1.0)	53 (1.1)	68 (1.0)	56 (1.0)	48 (0.9)
Bulgaria	540 (6.3)	60 (1.2)	60 (1.4)	65 (1.3)	62 (1.5)	62 (1.1)	54 (1.6)	47 (1.5)
Canada	527 (2.4)	59 (0.5)	64 (0.6)	58 (0.6)	54 (0.7)	69 (0.5)	51 (0.7)	48 (0.7)
Colombia	385 (3.4)	29 (0.8)	31 (0.9)	29 (0.9)	28 (0.9)	37 (1.0)	25 (1.5)	23 (0.9)
Cyprus	474 (1.9)	48 (0.5)	50 (0.6)	47 (0.6)	48 (0.7)	53 (0.6)	44 (0.9)	40 (0.7)
Czech Republic	564 (4.9)	66 (1.1)	69 (1.1)	66 (1.1)	65 (1.3)	68 (0.9)	62 (1.2)	52 (1.3)
Denmark	502 (2.8)	52 (0.7)	53 (0.9)	54 (0.9)	45 (0.7)	67 (0.9)	49 (1.0)	41 (0.8)
England and Wales	506 (2.6)	53 (0.7)	54 (0.8)	54 (1.0)	49 (0.9)	66 (0.7)	50 (0.9)	41 (1.1)
France	538 (2.9)	61 (0.8)	64 (0.8)	66 (0.8)	54 (1.0)	71 (0.8)	57 (0.9)	49 (0.9)
Germany	509 (4.5)	54 (1.1)	58 (1.1)	51 (1.4)	48 (1.3)	64 (1.2)	51 (1.1)	42 (1.3)
Greece	484 (3.1)	49 (0.7)	53 (0.8)	51 (0.7)	46 (0.8)	56 (0.8)	43 (0.9)	39 (1.1)
Hong Kong	588 (6.5)	70 (1.4)	72 (1.4)	73 (1.5)	70 (1.5)	72 (1.3)	65 (1.7)	62 (1.4)
Hungary	537 (3.2)	62 (0.7)	65 (0.8)	60 (0.8)	63 (0.9)	66 (0.7)	56 (0.8)	47 (0.9)
Iceland	487 (4.5)	50 (1.1)	54 (1.2)	51 (1.4)	40 (1.3)	63 (1.1)	45 (1.4)	38 (1.4)
Iran	528 (2.2)	38 (0.6)	39 (0.6)	43 (0.8)	37 (0.8)	41 (0.6)	29 (1.2)	36 (0.8)
Ireland	527 (5.1)	59 (1.2)	65 (1.2)	51 (1.3)	53 (1.3)	69 (1.1)	53 (1.3)	51 (1.2)
Israel	522 (6.2)	57 (1.3)	60 (1.4)	57 (1.4)	61 (1.6)	63 (1.3)	48 (1.6)	43 (1.6)
Japan	605 (1.9)	73 (0.4)	75 (0.4)	80 (0.4)	72 (0.6)	78 (0.4)	67 (0.5)	61 (0.5)
Kuwait	392 (2.5)	30 (0.7)	27 (0.8)	38 (1.0)	30 (1.0)	38 (1.0)	23 (1.0)	21 (0.7)
Latvia	493 (3.1)	51 (0.8)	53 (0.9)	57 (0.8)	51 (0.9)	56 (0.8)	47 (0.9)	39 (0.9)
Lithuania	477 (3.5)	48 (0.9)	51 (1.0)	53 (1.1)	47 (1.2)	52 (1.0)	43 (0.9)	35 (0.9)
Netherlands	541 (6.7)	60 (1.6)	62 (1.6)	59 (1.8)	53 (1.6)	72 (1.7)	57 (1.6)	51 (1.9)
New Zealand	508 (4.5)	54 (1.0)	57 (1.1)	54 (1.1)	49 (1.1)	66 (1.0)	48 (1.2)	42 (1.0)
Norway	503 (2.2)	54 (0.5)	58 (0.6)	51 (0.6)	45 (0.7)	66 (0.6)	51 (0.6)	40 (0.6)
Portugal	454 (2.5)	43 (0.7)	44 (0.7)	44 (0.8)	40 (0.8)	54 (0.7)	39 (0.7)	32 (0.8)
Romania	482 (4.0)	49 (1.0)	48 (1.0)	52 (0.9)	52 (1.3)	49 (1.0)	48 (1.1)	42 (1.2)
Russian Federation	535 (5.3)	60 (1.3)	62 (1.2)	63 (1.4)	63 (1.5)	60 (1.2)	56 (1.5)	48 (1.5)
Scotland	498 (5.5)	52 (1.3)	53 (1.3)	52 (1.4)	46 (1.5)	65 (1.3)	48 (1.6)	40 (1.4)
Singapore	643 (4.9)	79 (0.9)	84 (0.8)	76 (1.0)	76 (1.1)	79 (0.8)	77 (1.0)	75 (1.0)
Slovak Republic	547 (3.3)	62 (0.8)	66 (0.8)	63 (0.8)	62 (0.9)	62 (0.7)	60 (0.9)	49 (1.0)
Slovenia	541 (3.1)	61 (0.7)	63 (0.7)	60 (0.9)	61 (0.8)	66 (0.7)	59 (0.9)	49 (0.8)
South Africa	354 (4.4)	24 (1.1)	26 (1.4)	24 (1.0)	23 (1.1)	26 (1.2)	18 (1.1)	21 (0.9)
South Korea	607 (2.4)	72 (0.5)	74 (0.5)	75 (0.6)	69 (0.6)	78 (0.6)	66 (0.7)	62 (0.6)
Spain	487 (2.0)	51 (0.5)	52 (0.5)	49 (0.6)	54 (0.8)	60 (0.7)	44 (0.7)	40 (0.8)
Sweden	519 (3.0)	56 (0.7)	62 (0.8)	48 (0.7)	44 (0.9)	70 (0.7)	56 (0.9)	44 (0.9)
Switzerland	545 (2.8)	62 (0.6)	67 (0.7)	60 (0.8)	53 (0.7)	72 (0.7)	61 (0.8)	52 (0.7)
Thailand	522 (5.7)	57 (1.4)	60 (1.5)	62 (1.3)	53 (1.7)	63 (1.1)	50 (1.4)	51 (1.5)
United States	500 (4.6)	53 (1.1)	59 (1.1)	48 (1.2)	51 (1.2)	65 (1.1)	40 (1.1)	42 (1.1)

NR = not reported

NOTE: Standard errors are shown in parentheses.

SOURCE: A. Beaton, I. Mullis, M. Martin, E. Gonzalez, D. Kelly, and T. Smith, *Mathematics Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1996).

See figure 1-13.

Appendix table 1-14.
Average percentage correct on TIMSS mathematics assessment, by country, grade, and sex: 1994-95

Country	Grade 4		Grade 8	
	Boys	Girls	Boys	Girls
Australia	63 (0.7)	63 (0.8)	57 (1.2)	59 (1.1)
Austria	66 (0.9)	64 (0.8)	63 (0.8)	61 (1.2)
Belgium (Flemish)	NP	NP	65 (2.0)	66 (1.9)
Belgium (French)	NP	NP	59 (1.1)	58 (1.0)
Canada	61 (1.1)	60 (1.2)	59 (0.7)	59 (0.6)
Colombia	NP	NP	30 (1.6)	29 (0.9)
Cyprus	55 (0.8)	53 (0.7)	47 (0.6)	48 (0.6)
Czech Republic	67 (0.7)	66 (0.7)	67 (1.0)	64 (1.3)
Denmark	NP	NP	54 (0.8)[a]	50 (0.9)
England and Wales	57 (0.8)	56 (0.9)	53 (1.3)	53 (0.9)
France	NP	NP	62 (0.8)	61 (0.9)
Germany	NP	NP	54 (1.3)	54 (1.2)
Greece	50 (1.2)	51 (0.9)	51 (0.9)	48 (0.7)
Hong Kong	73 (1.1)	73 (0.8)	72 (1.7)	68 (1.7)
Hungary	64 (0.8)	64 (0.9)	61 (0.8)	62 (0.8)
Iceland	50 (1.0)	49 (0.9)	49 (1.3)	50 (1.3)
Iran	39 (1.4)	37 (1.1)	39 (0.8)	36 (0.8)
Ireland	63 (0.9)	64 (0.9)	60 (1.6)	58 (1.4)
Israel	60 (1.1)	59 (1.0)	61 (1.5)	55 (1.5)
Japan	75 (0.5)	74 (0.5)	74 (0.5)	73 (0.4)
Latvia	58 (1.2)	60 (1.1)	52 (1.0)	51 (0.8)
Lithuania	NP	NP	48 (1.1)	49 (1.0)
Netherlands	71 (0.8)[a]	68 (0.8)	61 (1.8)	59 (1.6)
New Zealand	52 (1.3)	54 (0.9)	55 (1.4)	53 (1.3)
Norway	54 (0.9)	53 (0.8)	54 (0.6)	53 (0.6)
Portugal	48 (0.8)	48 (0.8)	44 (0.8)	42 (0.7)
Romania	NP	NP	49 (1.1)	49 (1.0)
Russian Federation	NP	NP	59 (1.4)	61 (1.3)
Scotland	58 (0.9)	58 (0.9)	53 (1.7)	50 (1.3)
Singapore	75 (0.9)	76 (1.0)	79 (1.1)	79 (1.0)
Slovak Republic	NP	NP	63 (0.9)	62 (0.8)
Slovenia	64 (0.7)	65 (0.9)	62 (0.8)	60 (0.7)
South Africa	NP	NP	25 (1.7)	22 (1.0)
South Korea	77 (0.4)[a]	75 (0.5)	73 (0.6)[a]	70 (0.7)
Spain	NP	NP	52 (0.7)	50 (0.7)
Sweden	NP	NP	56 (0.8)	56 (0.8)
Switzerland	NP	NP	63 (0.8)	61 (0.7)
Thailand	49 (1.3)	52 (1.0)	56 (1.4)	58 (1.7)
United States	63 (0.7)	62 (0.7)	53 (1.2)	53 (1.1)

NP = did not participate in grade 4 assessment

NOTE: Standard errors are shown in parentheses.

[a] Difference between the sexes is statistically significant at the 0.05 level, adjusted for multiple comparisons.

SOURCES: A. Beaton, I. Mullis, M. Martin, E. Gonzalez, D. Kelly, and T. Smith, *Mathematics Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1996); and I. Mullis, M. Martin, A. Beaton, E. Gonzalez, D. Kelly, and T. Smith, *Mathematics Achievement in the Primary School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1997).

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Appendix table 1-15.

Students scoring in the top 10th percentile on the TIMSS science and mathematics assessments, by country and grade: 1994-95

Country	Science		Mathematics	
	Grade 4	Grade 8	Grade 4	Grade 8
Australia	14 (0.7)	16 (0.9)	12 (0.7)	11 (0.9)
Austria	10 (0.9)	16 (0.9)	11 (1.1)	11 (0.7)
Belgium (Flemish)	NP	10 (0.8)	NP	17 (1.2)
Belgium (French)	NP	1 (0.2)	NP	6 (0.6)
Bulgaria	NP	21 (1.4)	NP	16 (1.9)
Canada	9 (0.7)	9 (0.6)	7 (0.8)	7 (0.7)
Colombia	NP	0 (0.1)	NP	0 (0.0)
Cyprus	1 (0.1)	1 (0.2)	4 (0.5)	2 (0.3)
Czech Republic	11 (1.0)	19 (1.6)	15 (1.3)	18 (1.9)
Denmark	NP	2 (0.3)	NP	4 (0.5)
England and Wales	13 (1.0)	17 (0.9)	7 (0.7)	7 (0.6)
France	NP	1 (0.2)	NP	7 (0.8)
Germany	NP	11 (1.0)	NP	6 (0.7)
Greece	1 (0.2)	4 (0.4)	3 (0.5)	3 (0.4)
Hong Kong	4 (0.7)	7 (0.8)	18 (1.5)	27 (2.1)
Hungary	5 (0.6)	14 (0.8)	11 (1.1)	11 (0.8)
Iceland	3 (0.4)	2 (0.5)	1 (0.3)	1 (0.3)
Iran	0 (0.1)	1 (0.1)	0 (0.1)	0 (0.0)
Ireland	7 (0.6)	12 (0.9)	10 (0.7)	9 (1.0)
Israel	3 (0.5)	11 (1.2)	6 (0.7)	6 (0.9)
Japan	11 (0.6)	18 (0.6)	23 (0.9)	32 (0.8)
Kuwait	0 (0.1)	0 (0.0)	0 (0.1)	0 (0.0)
Latvia	4 (1.2)	2 (0.3)	6 (1.3)	3 (0.5)
Lithuania	NP	1 (0.3)	NP	1 (0.3)
Netherlands	5 (0.6)	12 (1.1)	13 (1.1)	10 (1.6)
New Zealand	9 (0.9)	11 (0.9)	3 (0.7)	6 (0.8)
Norway	6 (0.6)	7 (0.5)	2 (0.3)	4 (0.4)
Portugal	1 (0.2)	1 (0.1)	1 (0.2)	0 (0.1)
Romania	NP	5 (0.6)	NP	3 (0.4)
Russian Federation	NP	11 (0.8)	NP	10 (0.7)
Scotland	9 (0.8)	9 (1.1)	6 (0.8)	5 (0.9)
Singapore	11 (1.5)	31 (2.3)	39 (2.3)	45 (2.5)
Slovak Republic	NP	12 (0.9)	NP	12 (1.0)
Slovenia	6 (0.7)	14 (0.9)	11 (0.9)	11 (0.7)
South Africa	NP	1 (0.2)	NP	0 (0.0)
South Korea	17 (0.9)	18 (0.8)	26 (1.2)	34 (1.1)
Spain	NP	4 (0.3)	NP	2 (0.2)
Sweden	NP	9 (0.6)	NP	5 (0.5)
Switzerland	NP	7 (0.6)	NP	11 (0.7)
Thailand	0 (0.1)	4 (0.5)	1 (0.2)	7 (1.2)
United States	16 (0.9)	13 (0.8)	9 (0.8)	5 (0.6)

NP = did not participate in grade 4 assessment

SOURCES: A. Beaton, I. Mullis, M. Martin, E. Gonzalez, D. Kelly, and T. Smith, *Mathematics Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1996); and I. Mullis, M. Martin, A. Beaton, E. Gonzalez, D. Kelly, and T. Smith, *Mathematics Achievement in the Primary School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1997). *Science & Engineering Indicators – 1998*

Appendix table 1-16.

Students who report "never or almost never" using computers in science and mathematics courses, by country and grade: 1994-95

	Mathematics: Grade 4		Mathematics: Grade 8		Science: Grade 8	
Country	Percentage of students	Mean TIMSS achievement	Percentage of students	Mean TIMSS achievement	Percentage of students	Mean TIMSS achievement
Australia	66 (4.5)	548 (5.3)	78 (3.2)	531 (5.3)	NA	NA
Austria	98 (1.6)	560 (3.5)	69 (4.5)	551 (5.6)	85 (2.6)	565 (3.1)
Belgium (Flemish)	NA	NA	99 (0.7)	574 (4.6)	98 (1.0)	555 (5.9)
Belgium (French)	NA	NA	95 (2.4)	543 (4.4)	95 (2.0)	483 (3.5)
Canada	58 (4.0)	540 (4.5)	82 (3.5)	533 (2.9)	76 (3.3)	536 (2.9)
Colombia	NA	NA	94 (2.2)	387 (3.8)	95 (2.5)	413 (4.5)
Cyprus	86 (5.1)	508 (4.2)	89 (3.3)	468 (2.9)	92 (1.1)	456 (2.6)
Czech Republic	97 (1.7)	5[illegible] (3.3)	74 (5.4)	560 (6.4)	93 (2.0)	573 (4.6)
Denmark	NA	NA	38 (4.5)	500 (4.5)	63 (5.9)	482 (4.4)
England and Wales	NA	NA	53 (3.9)	517 (5.9)	70 (3.3)	567 (6.9)
France	NA	NA	86 (3.2)	541 (3.3)	97 (1.2)	499 (2.5)
Germany	NA	NA	87 (3.1)	510 (5.8)	95 (1.8)	536 (6.2)
Greece	99 (1.4)	495 (4.1)	85 (2.9)	481 (3.3)	93 (3.2)	498 (2.2)
Hong Kong	99 (0.8)	589 (4.3)	90 (3.5)	590 (7.3)	95 (2.5)	523 (5.3)
Hungary	NA	NA	NA	NA	NA	NA
Iceland	NA	NA	NA	NA	73 (6.1)	489 (4.5)
Iran	99 (1.1)	428 (4.1)	93 (5.5)	430 (2.3)	99 (0.5)	469 (2.4)
Ireland	90 (3.2)	549 (3.7)	99 (0.9)	528 (6.0)	96 (1.4)	540 (6.0)
Israel	NA	NA	NA	NA	75 (8.0)	538 (8.3)
Japan	93 (2.3)	598 (2.1)	90 (2.7)	604 (2.5)	84 (2.8)	572 (2.0)
Kuwait	98 (1.3)	401 (3.4)	73 (7.1)	393 (2.9)	78 (7.7)	427 (4.5)
Latvia	95 (2.0)	522 (5.0)	97 (1.6)	490 (3.3)	91 (1.5)	485 (2.6)
Lithuania	NA	NA	94 (1.8)	480 (4.1)	96 (1.1)	477 (4.2)
Netherlands	65 (5.0)	581 (4.9)	NA	NA	85 (2.6)	559 (7.4)
New Zealand	69 (3.8)	499 (4.6)	86(3.1)	506(4.4)	90 (2.7)	526 (4.7)
Norway	80 (3.7)	502 (3.6)	90(2.6)	507(2.7)	96 (1.9)	525 (2.3)
Portugal	98 (1.2)	475 (3.7)	97(1.5)	454(2.6)	99 (0.5)	480 (2.5)
Romania	NA	NA	96 (1.7)	481 (4.4)	94 (1.3)	487 (4.7)
Russian Federation	NA	NA	78 (2.6)	533 (6.8)	88 (1.7)	538 (4.6)
Scotland	NA	NA	NA	NA	NA	NA
Singapore	66 (4.2)	627 (5.7)	92 (2.7)	643 (5.3)	95 (1.5)	606 (5.8)
Slovak Republic	NA	NA	95 (1.5)	543 (3.3)	96 (2.0)	546 (3.9)
Slovenia	92 (2.8)	549 (3.5)	69 (4.5)	539 (4.5)	60 (3.1)	556 (3.5)
South Korea	96 (1.7)	610 (2.2)	96 (1.6)	610 (2.5)	96 (1.7)	566 (2.2)
Spain	NA	NA	89 (3.1)	488 (2.6)	92 (2.7)	519 (2.1)
Sweden	NA	NA	74 (2.9)	519 (4.1)	NA	NA
Switzerland	NA	NA	87 (3.2)	549 (5.6)	78 (4.3)	527 (4.9)
Thailand	96 (2.6)	491 (5.3)	97 (2.0)	528 (7.5)	92 (3.6)	530 (5.3)
United States	60 (4.1)	546 (4.7)	76 (3.1)	502 (5.9)	NA	NA

NA = not available; TIMSS = Third International Mathematics and Science Study

NOTE: Standard errors are shown in parentheses.

SOURCES: A. Beaton, I. Mullis, M. Martin, E. Gonzalez, D. Kelly, and T. Smith, *Mathematics Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1996); I. Mullis, M. Martin, A. Beaton, E. Gonzalez, D. Kelly, and T. Smith, *Mathematics Achievement in the Primary School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1997); and A. Beaton, M. Martin, I. Mullis, E. Gonzalez, T. Smith, and D. Kelly, *Science Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1996). A. Beaton, M. Martin, I. Mullis, E. Gonzalez, T. Smith, and D. Kelly, *Science Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1996); and M. Martin, I. Mullis, A. Beaton, E. Gonzalez, T. Smith, and D. Kelly, *Science Achievement in the Primary School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1997).

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Appendix table 1-17.

Average number of hours per day students report spending on out-of-school TV and study time, by country and grade: 1994-95

	Grade 4			Grade 8			
	Time spent:			Time spent:			
Country	Watching TV or videos	On math homework or studying	On science homework or studying	Watching TV or videos	Studying or doing homework	On math homework or studying	On science homework or studying
Australia	2.0 (0.05)	0.8 (0.02)	0.4 (0.02)	2.4 (0.05)	2.0 (0.04)	0.7 (0.02)	0.5 (0.01)
Austria	1.4 (0.04)	1.0 (0.03)	0.9 (0.03)	1.9 (0.06)	2.4 (0.07)	0.8 (0.02)	0.7 (0.03)
Belgium (Flemish)	NA	NA	NA	2.0 (0.05)	3.4 (0.07)	1.1 (0.03)	0.8 (0.02)
Belgium (French)	NA	NA	NA	1.9 (0.08)	3.0 (0.07)	1.0 (0.02)	0.8 (0.02)
Canada	1.9 (0.04)	0.8 (0.02)	0.6 (0.03)	2.3 (0.04)	2.2 (0.07)	0.7 (0.02)	0.6 (0.02)
Colombia	NA	NA	NA	2.2 (0.07)	4.6 (0.15)	1.3 (0.06)	1.2 (0.06)
Cyprus	1.8 (0.05)	1.1 (0.03)	0.8 (0.03)	2.3 (0.04)	3.6 (0.06)	1.2 (0.02)	0.9 (0.02)
Czech Republic	1.7 (0.04)	0.7 (0.02)	0.6 (0.02)	2.6 (0.05)	1.8 (0.05)	0.6 (0.02)	0.6 (0.02)
Denmark	NA	NA	NA	2.2 (0.06)	1.4 (0.05)	0.5 (0.02)	0.3 (0.02)
England and Wales	2.2 (0.04)	NA	NA	2.7 (0.07)	NA	NA	NA
France	NA	NA	NA	1.5 (0.04)	2.7 (0.05)	0.9 (0.02)	0.6 (0.01)
Germany	NA	NA	NA	1.9 (0.04)	2.0 (0.05)	0.6 (0.02)	0.6 (0.02)
Greece	1.3 (0.04)	1.6 (0.04)	1.3 (0.03)	2.1 (0.04)	4.4 (0.08)	1.2 (0.03)	1.2 (0.03)
Hong Kong	1.5 (0.04)	1.3 (0.03)	0.9 (0.02)	2.6 (0.05)	2.5 (0.06)	0.9 (0.02)	0.6 (0.02)
Hungary	2.3 (0.05)	1.0 (0.03)	1.0 (0.03)	3.0 (0.06)	3.1 (0.06)	0.8 (0.02)	1.1 (0.02)
Iceland	1.2 (0.04)	0.8 (0.02)	0.3 (0.02)	2.2 (0.05)	2.4 (0.07)	0.9 (0.03)	0.6 (0.03)
Iran	1.3 (0.05)	2.3 (0.07)	2.1 (0.06)	1.8 (0.06)	6.4 (0.13)	2.0 (0.05)	1.9 (0.05)
Ireland	1.9 (0.05)	0.8 (0.02)	0.4 (0.02)	2.1 (0.03)	2.7 (0.05)	0.7 (0.02)	0.6 (0.01)
Israel	2.5 (0.06)	1.1 (0.05)	0.9 (0.04)	3.3 (0.10)	2.8 (0.10)	1.0 (0.04)	0.6 (0.03)
Japan	1.9 (0.03)	0.9 (0.02)	0.4 (0.02)	2.6 (0.04)	2.3 (0.04)	0.8 (0.01)	0.6 (0.01)
Kuwait	1.4 (0.03)	1.9 (0.05)	1.8 (0.05)	1.9 (0.07)	5.3 (0.12)	1.6 (0.04)	1.5 (0.05)
Latvia	2.3 (0.07)	1.0 (0.03)	0.8 (0.03)	2.6 (0.05)	2.7 (0.05)	0.9 (0.02)	0.6 (0.02)
Lithuania	NA	NA	NA	2.8 (0.05)	2.7 (0.06)	0.8 (0.02)	0.7 (0.02)
Netherlands	1.7 (0.06)	0.5 (0.03)	0.4 (0.03)	2.5 (0.09)	2.2 (0.04)	0.6 (0.01)	0.6 (0.01)
New Zealand	2.0 (0.06)	0.8 (0.03)	0.5 (0.02)	2.5 (0.05)	2.1 (0.05)	0.7 (0.02)	0.6 (0.01)
Norway	1.7 (0.04)	0.6 (0.02)	0.4 (0.02)	2.5 (0.04)	2.3 (0.04)	0.7 (0.02)	0.6 (0.01)
Portugal	1.5 (0.05)	1.3 (0.03)	1.3 (0.03)	2.0 (0.04)	3.0 (0.05)	1.0 (0.02)	0.9 (0.02)
Romania	NA	NA	NA	1.9 (0.06)	5.0 (0.18)	1.8 (0.07)	1.6 (0.06)
Russian Federation	NA	NA	NA	2.9 (0.05)	2.9 (0.05)	0.9 (0.02)	1.0 (0.02)
Scotland	1.9 (0.06)	0.5 (0.02)	0.3 (0.02)	2.7 (0.05)	1.8 (0.04)	0.6 (0.02)	0.5 (0.01)
Singapore	NA	NA	NA	2.7 (0.05)	4.6 (0.04)	1.4 (0.02)	1.3 (0.02)
Slovak Republic	NA	NA	NA	2.7 (0.05)	2.4 (0.04)	0.7 (0.01)	0.8 (0.02)
Slovenia	1.5 (0.04)	1.0 (0.03)	1.0 (0.03)	2.0 (0.04)	2.9 (0.05)	0.9 (0.02)	1.0 (0.02)
South Korea	1.5 (0.03)	1.0 (0.02)	0.8 (0.02)	2.0 (0.04)	2.5 (0.05)	0.8 (0.02)	0.6 (0.02)
Spain	NA	NA	NA	1.8 (0.05)	3.6 (0.06)	1.2 (0.02)	1.0 (0.02)
Sweden	NA	NA	NA	2.3 (0.04)	2.3 (0.04)	0.7 (0.01)	0.7 (0.01)
Switzerland	NA	NA	NA	1.3 (0.03)	2.7 (0.04)	0.9 (0.02)	0.7 (0.01)
Thailand	1.1 (0.09)	1.0 (0.03)	0.7 (0.03)	2.1 (0.07)	3.5 (0.06)	1.2 (0.03)	1.0 (0.02)
United States	2.0 (0.04)	1.0 (0.03)	0.8 (0.02)	2.6 (0.07)	2.3 (0.04)	0.8 (0.02)	0.6 (0.01)

NA = not available

NOTE: Standard errors are shown in parentheses.

SOURCES: A. Beaton, M. Martin, I. Mullis, E. Gonzalez, T. Smith, and D. Kelly, *Science Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1996); M. Martin, I. Mullis, A. Beaton, E. Gonzalez, T. Smith, and D. Kelly, *Science Achievement in the Primary School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1997); A. Beaton, I. Mullis, M. Martin, E. Gonzalez, D. Kelly, and T. Smith, *Mathematics Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1996); and I. Mullis, M. Martin, A. Beaton, E. Gonzalez, D. Kelly, and T. Smith, *Mathematics Achievement in the Primary School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, 1997).

See figure 1-16.

Science & Engineering Indicators – 1998

Appendix table 1-18.

Grade 8 teachers' beliefs about the nature and teaching of mathematics and science: 1994-95

(Percentages)

Belief	Strongly disagree	Disagree	Agree	Strongly agree	Agree/strongly agree[a]
Mathematics					
Math is primarily an abstract subject	11.7 (2.6)	57.3 (4.6)	28.9 (3.9)	2.2 (0.9)	31.0 (3.9)
Math is primarily a formal way of representing the real world	1.0 (0.8)	19.9 (3.7)	67.9 (3.9)	11.2 (2.4)	79.1 (3.7)
Math is primarily a practical and structured guide for addressing real situations	0.0 (0.0)	11.2 (2.0)	69.5 (3.4)	19.3 (2.7)	88.8 (2.0)
If students are having difficulty, an effective approach is to give them more practice by themselves during the class	20.1 (3.6)	57.6 (4.5)	19.5 (3.2)	2.9 (0.9)	22.4 (3.0)
Some students have a natural talent for math and others do not	3.5 (1.4)	15.0 (2.4)	64.2 (3.8)	17.2 (3.4)	81.4 (2.8)
More than one representation should be used in teaching a math topic	0.0 (0.0)	1.7 (1.0)	46.6 (3.9)	51.7 (3.7)	98.3 (1.0)
Math should be learned as sets of algorithms or rules that cover all possibilities	10.9 (2.4)	53.9 (3.8)	32.6 (3.4)	2.6 (0.9)	35.2 (3.6)
Basic computational skills on the part of the teacher are sufficient for teaching elementary school math	42.3 (3.7)	40.4 (3.6)	11.5 (3.3)	5.8 (1.7)	17.3 (3.8)
A liking for and understanding of students are essential for teaching math	0.8 (0.3)	2.6 (1.0)	40.9 (4.2)	55.7 (4.1)	96.5 (1.1)
Science					
Science is primarily an abstract subject	17.9 (2.1)	63.9 (3.2)	18.1 (3.2)	0.1 (0.1)	18.2 (3.2)
Science is primarily a formal way of representing the real world	1.4 (0.8)	14.3 (2.3)	69.7 (4.3)	14.7 (3.6)	84.3 (2.6)
Science is primarily a practical and structured guide for addressing real situations	0.0 (0.0)	12.0 (2.9)	66.0 (4.6)	22.0 (3.8)	88.0 (2.9)
Some students have a natural talent for science and others do not	6.3 (1.5)	31.8 (3.8)	51.8 (3.7)	10.2 (2.8)	62.0 (3.2)
It is important for teachers to give students prescriptive and sequential directions for science experiments	3.3 (1.3)	20.8 (3.1)	48.9 (5.1)	27.1 (4.0)	75.8 (3.6)
Focusing on rules is a bad idea. It gives students the impression that the sciences are a set of procedures to be memorized	15.3 (2.9)	52.7 (4.8)	26.1 (3.2)	5.9 (2.9)	32.0 (3.7)
If students get into debates in class about ideas or procedures covering the sciences, it can harm their learning	56.5 (3.7)	40.7 (3.8)	0.7 (0.7)	2.1 (1.8)	2.8 (1.9)
Students see a science task as the same task when it is represented in two different ways	4.6 (1.5)	52.6 (3.9)	41.9 (4.2)	0.8 (0.4)	42.8 (4.2)
A liking for and understanding of students are essential for teaching science	1.3 (0.8)	9.1 (2.7)	43.2 (3.6)	46.4 (4.0)	89.6 (2.7)

NOTES: Data reflect the beliefs of grade 8 mathematics and science teachers surveyed as part of the Third International Mathematics and Science Study. Responses are to the question: *"To what extent do you agree or disagree with each of the following statements?"* Standard errors are shown in parentheses. Details may not add to totals because of rounding.

[a] Data in this column reflect the combined categories "Agree" and "Strongly agree."

SOURCE: T. Williams, D. Levine, L. Martin, P. Butler, C. Heid, and J. Haynes, *Mathematics and Science in the Eighth Grade*, report prepared for the National Center for Education Statistics (Rockville, MD: Westat, Inc., 1997).

See figure 1-19.

Science & Engineering Indicators – 1998

Appendix table 1-19.

Grade 8 teachers' perceptions of student skills required for success in mathematics and science: 1994-95

(Percentages)

Skill	Not important	Somewhat important	Very important
Mathematics			
Remember formulas and procedures	3.0 (1.1)	54.0 (3.5)	43.0 (3.5)
Think in sequential manner	0.6 (0.6)	20.0 (2.7)	79.5 (2.8)
Understand concepts	0.0 (0.0)	11.1 (3.0)	88.9 (3.0)
Think creatively	2.0 (0.9)	32.7 (3.8)	65.4 (4.0)
Understand math use in real world	0.0 (0.0)	18.3 (2.7)	81.7 (2.7)
Support solutions	2.4 (2.4)	16.9 (3.3)	80.8 (4.1)
Science			
Remember formulas and procedures	10.8 (2.4)	63.7 (4.1)	25.5 (4.0)
Think in sequential manner	1.3 (0.9)	19.1 (2.5)	79.6 (2.9)
Understand concepts	0.7 (0.7)	15.4 (2.4)	84.0 (2.5)
Think creatively	0.2 (0.2)	26.7 (3.6)	73.0 (3.7)
Understand science use in real world	0.3 (0.3)	20.5 (3.4)	79.2 (3.5)
Support solutions	0.0 (0.0)	13.9 (3.0)	86.1 (3.0)

NOTES: Data reflect the beliefs of grade 8 mathematics and science teachers surveyed as part of the Third International Mathematics and Science Study. Responses are to the statement: *"To be good at mathematics [science] at school, how important do you think it is for students to...?"* Standard errors are shown in parentheses. Details may not add to totals because of rounding.

SOURCE: T. Williams, D. Levine, L. Martin, P. Butler, C. Heid, and J. Haynes, *Mathematics and Science in the Eighth Grade*, report prepared for the National Center for Education Statistics, (Rockville, MD: Westat, Inc., 1997).

See figure 1-20

Science & Engineering Indicators – 1998

Appendix table 1-20.

Requirements for state teacher license: 1996

State	Major in subject field[a]	Written test	Performance assessment[b]
Alabama	No	–	–
Alaska	Yes	–	Yes
Arizona	–	–	–
Arkansas	No	Yes	–
California	Yes[c]	Yes	–
Colorado	Yes[c]	Yes	Yes
Connecticut	Yes[c]	Yes	Yes
Delaware	No	Yes	–
Florida	No	Yes	Yes
Georgia	Yes	Yes	–
Hawaii	Yes	Yes	–
Idaho	Yes	–	–
Illinois	Yes	Yes	–
Indiana	Yes	Yes	–
Iowa	Yes[c]	–	–
Kansas	No	Yes	–
Kentucky	Yes	Yes	Yes
Louisiana	–	–	–
Maine	Yes	Yes	–
Maryland	No	Yes	Yes
Massachusetts	Yes[c]	Yes	–
Michigan	No	Yes	Yes
Minnesota	Yes	Yes	–
Mississippi	Yes	Yes	Yes
Missouri	Yes[c]	Yes	Yes
Montana	No	Yes	–
Nebraska	No	Yes	–
Nevada	Yes	Yes	–
New Hampshire	Yes[c]	–	–
New Jersey	–	–	–
New Mexico	Yes	Yes	–
New York	No	Yes	Yes
North Carolina	No	Yes	Yes
North Dakota	Yes	–	Yes
Ohio	No	Yes	Yes
Oklahoma	No	Yes	–
Oregon	No	Yes	Yes
Pennsylvania	No	Yes	–
Rhode Island	Yes	–	–
South Carolina	Yes	Yes	Yes
South Dakota	Yes	–	Yes
Tennessee	Yes	–	–
Texas	Yes[c]	Yes	–
Utah	Yes	–	–
Vermont	No	–	–
Virginia	Yes[c]	Yes	–
Washington	No	–	Yes
West Virginia	No	Yes	–
Wisconsin	Yes	Yes	Yes
Wyoming	Yes	–	–

– = data not available

[a] A major in education is not accepted. "Yes" denotes that a subject major is required for middle and/or secondary teaching license.

[b] Performance assessment comprises one or more of the following techniques: portfolios, classroom observations, simulated exercises.

[c] A subject major is required for all teachers K-12, not just for middle/secondary teachers.

SOURCE: Council of Chief State School Officers, *Key State Education Policies on K-12 Education: Content Standards, Graduation, Teacher Licensure, Time and Attendance* (Washington, DC: 1996).

Science & Engineering Indicators – 1998

Appendix table 1-21.

National trends in science coursetaking at age 17, by sex and race/ethnicity: 1986, 1990, 1992, and 1994

Course and year	Total		Male		Female		White		Black		Hispanic	
	Average NAEP science scale score	Percentage of students	Average NAEP science scale score	Percentage of students	Average NAEP science scale score	Percentage of students	Average NAEP science scale score	Percentage of students	Average NAEP science scale score	Percentage of students	Average NAEP science scale score	Percentage of students
General science												
1986	290 (1.3)[a]	83 (1.3)	298 (1.7)	84 (1.5)	283 (1.6)[a]	82 (1.6)	297 (1.5)[a]	84 (1.6)	257 (2.8)	83 (2.6)	264 (4.5)	82 (3.5)
1990	292 (1.1)	82 (1.3)	298 (1.4)	84 (1.3)	286 (1.4)	81 (1.7)	300 (1.1)[a]	84 (1.4)	258 (4.5)	76 (3.1)	266 (4.8)	82 (4.4)
1992	297 (1.3)[b]	94 (1.0)	301 (1.6)	86 (1.1)	290 (1.5)[b]	83 (1.5)	304 (1.3)[b]	86 (1.0)	259 (3.9)	79 (3.6)	274 (5.4)	79 (3.2)
1994	296 (1.6)[b]	83 (1.3)	302 (2.2)	84 (1.5)	291 (1.8)[b]	82 (1.4)	306 (1.7)[b]	84 (1.5)	259 (3.3)	80 (1.9)	268 (5.1)	77 (2.4)
Biology												
1986	294 (1.5)[a]	88 (1.0)[a]	301 (1.8)	87 (1.1)[a]	287 (1.7)[a]	88 (1.1)[a]	301 (1.8)[a]	89 (1.1)[a]	260 (3.1)	84 (2.7)	265 (3.7)	84 (3.4)
1990	296 (1.0)[a]	89 (0.9)[a]	302 (1.3)	87 (1.1)[a]	290 (1.5)	91 (1.0)	304 (1.0)[a]	90 (0.9)[a]	260 (4.6)	87 (2.2)	270 (5.0)	79 (4.4)
1992	299 (1.1)[b]	92 (0.9)[b]	305 (1.5)	91 (1.2)[b]	293 (1.4)[b]	93 (1.0)[b]	308 (1.1)[b]	93 (1.0)[b]	260 (3.1)	92 (1.9)[b]	276 (4.5)	87 (4.1)
1994	300 (1.2)[b]	93 (0.9)[b]	306 (1.8)	92 (0.9)[b]	294 (1.3)[b]	93 (1.0)[b]	310 (1.3)[b]	94 (0.9)[b]	263 (2.7)	93 (1.8)[b]	273 (6.1)	84 (3.4)
Chemistry												
1986	312 (2.1)	40 (1.6)[a]	319 (2.7)	42 (1.8)[a]	304 (2.2)	39 (2.1)[a]	317 (2.2)[a]	43 (1.8)[a]	275 (6.4)	29 (2.6)[a]	281 (8.7)	24 (2.2)[a]
1990	316 (1.4)	45 (1.5)[a]	324 (1.9)	45 (1.7)	310 (1.7)	45 (1.7)[a]	325 (1.3)[b]	46 (1.7)[a]	280 (7.3)	46 (4.0)[b]	295 (6.0)	31 (4.3)
1992	319 (1.0)[b]	49 (1.7)[b]	325 (1.5)	47 (1.9)	313 (1.5)[b]	51 (2.0)[b]	325 (1.3)[b]	52 (1.8)[b]	282 (3.6)	36 (3.2)[a]	298 (4.1)	36 (5.6)
1994	315 (1.7)	53 (2.1)[b]	322 (2.4)	50 (2.6)[b]	309 (1.9)	55 (2.3)[b]	324 (1.7)[b]	54 (2.5)[b]	278 (3.4)	51 (3.6)[b]	288 (6.3)	41 (3.0)[b]
Physics												
1986	296 (4.7)[a]	11 (0.9)[a]	305 (6.8)	14 (1.3)[a]	282 (3.8)[a]	8 (0.7)[a]	316 (4.4)	10 (0.8)[a]	239 (5.4)[a]	18 (3.5)	257 (17.6)	13 (2.8)
1990	304 (3.7)	14 (1.5)	311 (4.3)	16 (1.8)	295 (4.2)[a]	13 (1.5)[b]	317 (2.6)	13 (1.7)	263 (11.8)	15 (2.7)	253 (18.3)	17 (4.5)
1992	306 (3.9)	14 (1.1)[a]	310 (4.7)	15 (1.0)[a]	302 (4.1)[b]	12 (1.5)	319 (3.5)	13 (1.2)[a]	251 (7.4)	14 (1.9)	282 (11.1)	13 (2.3)
1994	314 (2.9)[b]	18 (1.2)[b]	318 (4.1)	20 (1.5)[b]	310 (3.3)[b]	16 (1.3)[b]	326 (3.2)	18 (1.4)[b]	268 (7.5)[†]	16 (2.0)	*	*

* = sample size insufficient to permit reliable estimates; NAEP = National Assessment of Educational Progress

NOTES: Scale scores range from 0 to 300. Significance tests for extreme percentages (either >90 or <10 percent) should be interpreted with caution. It can be said with 95 percent certainty that for each population of interest, the value for the whole population is within ±2 standard errors of the estimate for the sample. Use the standard error of difference in comparing estimates. Details may not add to totals because of rounding. Standard errors are shown in parentheses.

[a] Statistically significant difference from 1994 at the 0.05 level, adjusted for multiple comparisons.

[b] Statistically significant difference from 1986 at the 0.05 level, adjusted for multiple comparisons.

SOURCE: J. Campbell, C. Reese, C. O'Sullivan, and J. Dossey, *NAEP 1994: Trends in Academic Progress* (Washington, DC: National Center for Education Statistics, 1996).

Science & Engineering Indicators – 1998

Appendix table 1-22.

Highest level of mathematics courses taken at age 17, by sex and race/ethnicity: 1978 and 1994

	Total		Male		Female		White		Black		Hispanic	
Course and year	Average NAEP math scale score	Percentage of students	Average NAEP math scale score	Percentage of students	Average NAEP math scale score	Percentage of students	Average NAEP math scale score	Percentage of students	Average NAEP math scale score	Percentage of students	Average NAEP math scale score	Percentage of students
Prealgebra or general mathematics												
1978	267 (0.8)	20 (1.0)[a]	269 (1.0)[a]	21 (1.0)[a]	265 (0.9)	20 (1.1)[a]	272 (0.6)	18 (1.1)[a]	247 (1.6)[a]	31 (1.3)	256 (2.3)[a]	36 (3.1)
1994	272 (1.2)	9 (1.1)	274 (1.8)	11 (1.2)	268 (1.9)	8 (1.2)	275 (1.4)	9 (1.1)	*	*	*	*
Algebra 1												
1978	286 (0.7)	17 (0.6)	289 (0.9)	15 (0.6)	284 (1.0)	18 (0.7)[a]	291 (0.6)	17 (0.6)[a]	264 (1.5)[a]	19 (1.2)	273 (2.8)[a]	19 (2.1)
1994	288 (1.4)	15 (0.9)	289 (1.6)	16 (1.3)	286 (1.9)	14 (0.9)	292 (1.7)	14 (0.9)	275 (3.3)	21 (2.4)	*	*
Geometry												
1978	307 (0.7)[a]	16 (0.6)	310 (1.0)[a]	15 (0.5)	304 (0.8)[a]	18 (0.8)[a]	310 (0.6)[a]	17 (0.7)[a]	281 (1.9)	11 (0.8)[a]	294 (4.4)	12 (1.2)
1994	297 (1.7)	15 (0.8)	301 (2.1)	15 (0.9)	293 (1.8)	15 (1.1)	301 (1.5)	14 (1.0)	283 (3.8)	17 (2.2)	*	*
Algebra 2												
1978	321 (0.7)[a]	37 (1.2)[a]	325 (0.8)[a]	38 (1.2)[a]	318 (0.9)[a]	37 (1.3)[a]	325 (0.6)[a]	39 (1.3)[a]	292 (1.4)	28 (2.1)[a]	303 (2.9)	23 (2.5)[a]
1994	316 (1.0)	47 (1.6)	320 (1.5)	44 (1.9)	313 (1.1)	50 (2.0)	320 (1.0)	48 (1.9)	297 (2.5)	45 (3.4)	304 (4.1)	38 (3.5)
Precalculus or calculus												
1978	334 (1.4)[a]	6 (0.4)[a]	337 (2.0)	7 (0.5)[a]	329 (1.8)[a]	4 (0.4)[a]	338 (1.1)[a]	6 (0.4)[a]	297 (6.5)[a]	4 (0.6)	306 (6.1)	3 (0.9)
1994	340 (2.2)	13 (1.2)	343 (2.6)	13 (1.3)	337 (2.8)	12 (1.5)	344 (2.0)	14 (1.5)	*	*	*	*

* = sample size insufficient to permit reliable estimates

NOTES: It can be said with 95 percent certainty that for each population of interest, the value for the whole population is within ±2 standard errors of the estimate for the sample. Use the standard error of difference in comparing estimates. Details may not add to totals because a small percentage of students reported having taken other mathematics courses. Standard errors are shown in parentheses.

[a] Statistically significant difference between 1994 and the earliest year with available data at the 0.05 level; this is not adjusted for multiple comparisons.

SOURCE: J. Campbell, C. Reese, C. O'Sullivan, and J. Dossey, *NAEP 1994: Trends in Academic Progress* (Washington, DC: National Center for Education Statistics, 1996).

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Appendix table 1-23.
Frequency of calculator use in grade 8 mathematics and science classes, by type of activity: 1994-95

(Percentage of teachers reporting)

Activity	Hardly ever		Once or twice a month		Once or twice a week		Every day	
Mathematics								
Checking answers	17.4	(3.3)	10.8	(2.3)	16.4	(3.2)	55.4	(4.6)
Tests and exams	31.0	(3.9)	22.9	(3.7)	21.8	(3.4)	24.3	(4.6)
Routine computation	22.9	(3.6)	8.9	(2.2)	16.1	(3.0)	52.1	(5.1)
Solving complex problems	11.4	(2.5)	12.2	(2.3)	23.0	(3.8)	53.4	(4.7)
Exploring number concepts	23.6	(2.9)	17.6	(3.0)	22.7	(3.9)	36.1	(3.6)
Science								
Checking answers	50.8	(3.4)	29.7	(3.8)	17.2	(3.3)	2.3	(1.2)
Tests and exams	67.7	(3.5)	22.6	(3.0)	6.4	(2.2)	3.3	(1.4)
Routine computation	39.3	(4.0)	33.0	(4.5)	19.7	(3.2)	8.0	(1.8)
Solving complex problems	46.7	(3.7)	35.1	(3.9)	14.4	(3.3)	3.9	(1.3)
Exploring number concepts	68.7	(3.8)	19.6	(3.6)	10.4	(2.7)	1.4	(0.4)

NOTE: Percentages may not total 100 because of rounding. Standard errors are shown in parentheses.

SOURCE: T. Williams, D. Levine, L. Martin, P. Butler, C. Heid, and J. Haynes, *Mathematics and Science in the Eighth Grade*, report prepared for the National Center for Education Statistics (Rockville, MD: Westat, Inc., 1997).

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Appendix table 1-24.
Percentage of public secondary school students taught by teachers without at least a minor in the field, by field and selected classroom characteristics: 1990-91

Characteristic	English	Math	Science			Social studies	
			All sciences	Life science	Physical science	All social studies	History
Total	20.8	26.6	16.5	38.5	56.2	13.4	53.9
Achievement level of class							
Low achievement	28.2	33.7	26.6	48.7	66.7	18.4	60.1
Average achievement	19.0	25.6	15.2	33.7	58.0	12.5	52.1
High achievement	16.3	21.6	9.2	32.0	45.5	11.8	52.6
Type or track of class							
Low-track	24.7	33.5	20.4	42.3	66.8	14.3	55.1
Medium-track	11.8	15.7	9.2*	31.4	42.8	8.9	44.9
High-track	11.2	20.4*	7.2*	20.7	43.0	11.2	51.1
Minority enrollment of class							
Low minority	19.2	22.7	14.6	36.6	56.3	12.3	55.6
Medium minority	19.9	24.2	17.7	42.8	54.1	15.0	52.7
High minority	25.2	36.1	19.6	37.6	58.7	14.3	51.4
Grade level of class							
7th grade	32.2	48.8	31.8	60.4	73.8	23.9	56.3
8th grade	32.9	37.1	23.8	32.9*	75.7	19.7	60.5
9th grade	15.7	18.1	10.7	27.9	61.7	8.7	48.7
10th grade	11.1	16.8	8.9*	29.3	45.7	8.8	51.1
11th grade	11.2	15.9	6.4	23.5*	36.8	6.8	47.0
12th grade	13.9	24.2	13.1*	25.3*	41.0	11.3	62.4

*Coefficient of variation greater than 30 percent.

NOTE: The estimates for life science, physical science, and history represent the proportion of students taught by teachers without at least a minor in *those particular subfields*.

SOURCE: R. Ingersoll, *Out-of-Field Teaching and Educational Equality,* NCES 96-040. (Washington, DC: U.S. Department of Education, 1996).

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Appendix table 1-25.
Percentage of public schools and instructional rooms with Internet access, by school characteristics: 1994-96

Characteristic	Percentage of schools with Internet access			Percentage of instructional rooms with Internet access		
	1994	1995	1996	1994	1995	1996
All public schools	35 (1.5)	50 (1.8)	65 (1.8)	3 (0.3)	8 (0.7)	14 (1.0)
Instructional level						
Elementary	30 (1.9)	46 (2.4)	61 (2.1)	3 (0.4)	8 (1.0)	13 1.5)
Secondary	49 (2.4)	65 (2.7)	77 (1.8)	4 (0.6)	8 (1.0)	16 (1.5)
Percent minority enrollment						
Less than 6 percent	– –	52 (3.3)	65 (3.4)	– –	9 (1.4)	18 (2.4)
6 to 20 percent	– –	58 (4.4)	72 (3.0)	– –	10 (1.5)	18 (2.2)
21 to 49 percent	– –	54 (4.0)	65 (3.2)	– –	9 (2.1)	12 (2.3)
50 percent or more	– –	40 (3.8)	56 (4.6)	– –	3 (1.0)	5 (1.5)
Percent of students eligible for free or reduced-price school lunch						
Less than 11 percent	– –	62 (3.5)	78 (3.6)	– –	9 (1.6)	18 (2.9)
11 to 30 percent	– –	59 (3.6)	72 (3.1)	– –	10 (1.8)	16 (2.0)
31 to 70 percent	– –	47 (2.9)	58 (3.2)	– –	7 (1.6)	14 (1.8)
71 percent or more	– –	31 (4.3)	53 (5.2)	– –	3 (0.9)	7 (1.6)

– = data not available

NOTE: Instructional rooms include classrooms, computer and other labs, and library/media centers. Standard errors are shown in parentheses.

SOURCE: National Center for Education Statistics, "Advanced Telecommunications in U.S. Public Elementary and Secondary Schools, Fall 1996," *Statistics in Brief*, NCES 97-944 (Washington, DC: U.S. Department of Education, 1997).

See figure 1-17. *Science & Engineering Indicators – 1998*

Appendix table 1-26.
Proficiency of grade 8 mathematics students, by teachers' backgrounds in mathematics: 1988

Student proficiency level	Teachers have taken calculus or below		Teachers have taken advanced mathematics	
	And have no mathematics education	And have a mathematics education	And have no mathematics education	And have a mathematics education
Unable to perform simple mathematics operations on whole numbers	22	21	17	16
Able to perform simple arithmetic operations on whole numbers	40	43	39	37
Able to perform simple arithmetic operations with decimals, fractions and roots	21	24	21	25
Able to perform simple problem solving	17	13	22	22

SOURCE: B. Chaney, *Student Outcomes and the Professional Preparation of Eighth Grade Teachers in Science and Mathematics*, report prepared for the National Science Foundation (Rockville, MD: Westat, Inc., 1995).

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Appendix table 1-27.

Trends in average scale scores on the National Assessment of Educational Progress in mathematics, by age, sex, and race/ethnicity: 1973-96, selected years

	All students	Males	Females	Difference, male vs. female	Whites	Blacks	Difference, white vs. black	Hispanics	Difference, white vs. Hispanic
Age 9									
1973	219 (0.8)	218 (0.7)	220 (1.1)	-3 (1.3)	225 (1.0)	190 (1.8)	35 (2.1)	202 (2.4)	23 (2.6)
1978	219 (0.8)	217 (0.7)	220 (1.0)	-3 (1.3)	224 (0.9)	102 (1.1)	32 (1.5)	203 (2.2)	21 (2.4)
1982	219 (1.1)	217 (1.2)	221 (1.2)	-4 (1.7)	224 (1.1)	195 (1.6)	29 (2.0)	204 (1.3)	20 (1.7)
1986	222 (1.0)	222 (1.1)	222 (1.2)	0 (1.6)	227 (1.1)	202 (1.6)	25 (2.0)	205 (2.1)	22 (2.3)
1990	230 (0.8)	229 (0.9)	230 (1.1)	-1 (1.6)	235 (0.8)	208 (2.2)	27 (2.4)	214 (2.1)	21 (2.3)
1992	230 (0.8)	231 (1.0)	228 (1.0)	2 (1.4)	235 (0.8)	208 (2.0)	27 (2.2)	212 (2.3)	23 (2.5)
1994	231 (0.8)	232 (1.0)	230 (0.9)	2 (1.4)	237 (1.0)	212 (1.6)	25 (1.8)	210 (2.3)	27 (2.5)
1996	231 (0.8)	233 (1.2)	229 (0.7)	4 (1.4)	237 (1.0)	212 (1.4)	25 (1.8))	215 (1.7)	22 (2.0)
Age 13									
1973	266 (1.1)	265 (1.3)	267 (1.1)	-2 (1.7)	274 (0.9)	228 (1.9)	46 (2.1)	239 (2.2)	35 (2.4)
1978	264 (1.1)	264 (1.3)	265 (1.1)	-1 (1.7)	272 (0.8)	230 (1.9)	42 (2.1)	238 (2.0)	34 (2.1)
1982	269 (1.1)	296 (1.4)	268 (1.1)	1 (1.7)	274 (1.0)	240 (1.6)	34 (1.9)	252 (1.7)	22 (1.9)
1986	269 (1.2)	270 (1.1)	268 (1.5)	2 (1.9)	274 (1.3)	249 (2.3)	24 (2.6)	254 (2.9)	19 (3.2)
1990	270 (0.9)	271 (1.2)	270 (0.9)	2 (1.5)	276 (1.1)	249 (2.3)	27 (2.6)	255 (1.8)	22 (2.1)
1992	273 (0.9)	274 (1.1)	272 (1.0)	2 (1.5)	279 (0.9)	250 (1.9)	29 (2.1)	259 (1.8)	20 (2.0)
1994	274 (1.0)	276 (1.3)	273 (1.0)	3 (1.6)	281 (0.9)	252 (3.5)	29 (3.7)	256 (1.9)	25 (2.1)
1996	274 (0.8)	276 (0.9)	272 (1.0)	4 (1.4)	281 (0.9)	252 (1.3)	29 (1.6)	256 (1.6)	26 (1.9)
Age 17									
1973	304 (1.1)	309 (1.2)	301 (1.1)	8 (1.6)	310 (1.1)	270 (1.3)	40 (1.7)	272 (2.2)	33 (2.5)
1978	300 (1.0)	304 (1.0)	297 (1.0)	7 (1.4)	306 (0.9)	268 (1.3)	38 (1.6)	276 (2.3)	30 (2.4)
1982	299 (0.9)	302 (1.0)	296 (1.0)	6 (1.4)	304 (0.9)	272 (1.2)	32 (1.5)	277 (1.8)	27 (2.0)
1986	302 (0.9)	305 (1.2)	299 (1.0)	5 (1.5)	308 (1.0)	279 (2.1)	29 (2.3)	283 (2.9)	24 (3.0)
1990	305 (0.9)	306 (1.1)	303 (1.1)	3 (1.5)	310 (1.0)	289 (2.8)	21 (3.0)	284 (2.9)	26 (3.1)
1992	307 (0.9)	309 (1.1)	305 (1.1)	4 (1.5)	312 (0.8)	286 (2.2)	26 (2.4))	292 (2.6)	20 (2.8)
1994	306 (1.0)	309 (1.4)	304 (1.1)	4 (1.8)	312 (1.1)	286 (1.8)	27 (2.1)	291 (3.7)	22 (3.9)
1996	307 (1.2)	310 (1.3)	305 (1.4)	5 (1.9)	313 (1.4)	286 (1.7)	27 (2.2)	292 (2.1)	21 (2.5)

NOTES: Scale scores range from 0 to 300 for every grade level. Standard errors are shown in parentheses.

SOURCE: J. Campbell, C. Reese, C. O'Sullivan, and J. Dossey, *NAEP 1994: Trends in Academic Progress* (Washington, DC: National Center for Education Statistics, 1996).

See figure 1-9.

Science & Engineering Indicators – 1998

Appendix table 2-1.

Number of first university degrees and percentage of 24-year-olds who earn first university degrees in S&E, by region/country: Most recent year

Region/country	All first university degrees	Degree fields			24-year-olds			
		Natural sciences[a]	Social sciences[b]	Engineering	Total number	% with first univ. degree	% with NS&E degree	% with soc. sci. degree
Total, three world regions	5,208,205	764,820	642,777	739,051	64,944,472	8.0	2.3	1.0
Asia								
Total	2,043,677	301,877	280,775	343,774	48,543,046	4.2	1.3	0.6
China	325,484	54,394	32,075	148,844	24,413,600	1.3	0.8	0.1
Hong Kong	11,362	2,370	1,233	1,822	92,634	12.3	4.5	1.3
India	750,000	147,036	NA	29,000	15,545,800	4.8	1.1	NA
Indonesia	78,655	11,024	13,959	9,813	3,660,449	2.1	0.6	0.4
Japan	493,277	30,579	200,875	97,392	1,996,800	24.7	6.4	10.1
Malaysia	10,511	1,685	2,198	877	333,180	3.2	0.8	0.7
Singapore	5,599	2,103	1,820	1,676	50,000	11.2	7.6	3.6
South Korea	184,214	31,946	16,955	35,449	890,800	20.7	7.6	1.9
Taiwan	68,274	10,131	4,848	12,107	348,400	19.6	6.4	1.4
Thailand	116,301	10,609	6,812	6,794	1,211,383	9.6	1.4	0.6
Europe								
Total	1,713,423	309,837	138,896	283,530	10,479,620	16.4	5.7	1.3
European Union	982,939	149,180	77,532	132,101	5,674,706	17.3	5.0	1.4
Austria (long)	11,513	1,875	912	1,180	112,935	10.2	2.7	0.8
Belgium (long)	20,484	1,779	5,409	4,505	138,677	14.8	4.5	3.9
Denmark (short)	16,833	625	1,202	2,243	75,298	29.5	6.5	1.9
Denmark (long)	5,395	864	262	1,139				
Finland (short)	4,655	714	NA	2,325	63,174	22.4	9.0	1.3
Finland (long)	9,467	1,433	807	1,219				
France (long)	108,900	21,993	NA	20,562	855,915	12.7	5.0	NA
Germany (short)	71,367	12,224	10,101	25,502	1,354,866	14.5	5.8	1.4
Germany (long)	125,706	25,714	8,596	15,052				
Greece (long)	18,556	2,570	221	1,785	151,822	12.2	2.9	0.1
Ireland (short)	8,174	863	541	414	64,385	21.9	6.3	1.8
Ireland (long)	5,943	1,672	635	1,135				
Italy (short)	6,847	522	1,054	261	897,248	11.5	2.5	1.2
Italy (long)	96,278	12,563	9,371	8,755				
The Netherlands (long)	45,478	3,117	7,588	6,917	228,501	19.9	4.4	3.3
Portugal (short)	3,007	47	7	340	164,199	13.7	2.6	1.6
Portugal (long)	19,495	1,712	2,639	2,128				
Spain (short)	55,819	2,537	NA	6,720	659,319	20.9	3.7	0.9
Spain (long)	82,004	11,267	5,714	4,097				
Sweden (short)	8,126	785	1,141	135	124,567	12.7	3.3	1.1
Sweden (long)	7,644	867	171	2,369				
United Kingdom (short)[c]	251,248	43,437	21,161	23,318	783,800	32.1	8.5	2.7
European Free Trade Assoc.	32,378	2,468	2,485	5,224	176,587	18.3	4.4	1.4
Norway (short)	11,759	162	111	2,177	67,352	22.8	4.4	1.0
Norway (long)	3,620	605	575	NA				
Switzerland (short)	7,098	245	701	2,232	109,235	15.6	4.3	1.6
Switzerland (long)	9,901	1,456	1,098	815				
Central & Eastern Europe	698,106	158,189	58,879	146,205	4,628,327	15.1	6.6	1.3
Albania	3,963	896	165	535	63,583	6.2	2.3	0.3
Bulgaria	21,951	2,003	478	5,823	120,441	18.2	6.5	0.4
Czech Republic	19,566	2,310	354	5,532	154,028	12.7	5.1	0.2
Hungary (short)	7,725	663	NA	2,161	141,334	16.7	4.7	1.9
Hungary (long)	15,890	1,777	2,731	1,994				
Poland	60,224	7,786	4,940	9,680	527,999	11.4	3.3	0.9
Romania	34,240	3,985	287	16,114	374,828	9.1	5.4	0.1
Russia	445,006	127,655	33,236	90,746	2,019,464	22.0	10.8	1.6
Slovak Republic	9,149	1,014	112	3,059	82,430	11.1	4.9	0.1
Turkey	80,392	10,100	16,576	10,561	1,144,220	7.0	1.8	1.4
North America								
Total	1,451,105	153,106	223,106	111,747	5,921,806	24.5	4.5	3.8
Canada	147,001	14,260	26,067	8,482	381,002	38.6	6.0	6.8
Mexico	129,668	9,381	11,727	39,894	1,964,404	6.6	2.5	0.6
United States	1,174,436	129,465	185,312	63,371	3,576,400	32.8	5.4	5.2

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Appendix table 2-1.
Number of first university degrees and percentage of 24-year-olds who earn first university degrees in S&E, by region/country: Most recent year

NA = not available; NS&E = natural sciences and engineering

NOTES: Data are compiled from numerous national and international sources, and degree fields may not be strictly comparable. First university degrees in different countries are of different duration and may not be academically equivalent. In European countries, *short* degree programs are three years long; *long* degree programs take four to six years. U.K. data are for 1996. Data for China, Japan, Singapore, South Korea, Taiwan, Austria, Switzerland, and the United States are for 1995. Data for Finland, France, Germany, Italy, Portugal, Sweden, Norway, Bulgaria, Czech Republic, Russia, Slovak Republic, Canada, and Mexico are for 1994. Data for Hong Kong, Belgium, Denmark, Greece, Ireland, the Netherlands, Spain, Albania, Hungary, Poland, Romania, and Turkey are for 1993. Data for Indonesia and Thailand are for 1992. Indian and Malaysian data are for 1990.

[a] Natural sciences here include physical, earth, atmospheric, oceanographic, biological, and agricultural sciences, as well as mathematics and computer sciences.

[b] Social sciences include psychology, sociology, and other social sciences. Japanese social science data also include business administration. Mexican social science data are estimated.

[c] U.K. data include former colleges and polytechnics.

SOURCES: **ASIA: China**—National Research Center for Science and Technology for Development, unpublished tabulations, and UNESCO, *Statistical Yearbook* (Paris: 1996); **Hong Kong**—UNESCO (1996); **India**—Department of Science and Technology, *Research and Development Statistics 1994-95* (New Delhi: 1996); **Indonesia**—UNESCO (1996); **Japan**—Ministry of Education, Science, and Culture (Monbusho), *Monbusho Survey of Education* (Tokyo: annual series); **Malaysia**—UNESCO (1996); **Singapore**—National University of Singapore, *Annual Report* (Singapore: 1996); **South Korea**—Ministry of Education, *Statistical Yearbook of Education* (Seoul: 1996); **Taiwan**—Ministry of Education, *Educational Statistics of the Republic of China* (Taipei: 1996); **Thailand**—UNESCO (1996); **EUROPEAN UNION: Austria**—Austrian Central Statistical Office, unpublished tabulations; **Belgium**—Organisation for Economic Co-operation and Development and Centre for Educational Research and Innovation (OECD/CERI), unpublished tabulations, and UNESCO (1996) (social sciences); **Denmark**—Department of Higher Education, Ministry of Education, unpublished tabulations (1997); **Finland**—Central Statistical Office, unpublished tabulations (1997), and OECD/CERI; **France**—Ministère de l'Éducation Nationale, *Repères et Références Statistiques sur les Enseignements et la Formation* (Vanves, France: 1996); **Germany**—Statistisches Bundesamt Wiesbaden, *Prüfungen an Hochschulen* (Wiesbaden: 1996); **Greece**—National Statistical Service of Greece, unpublished tabulations (1997), and OECD/CERI; **Ireland**—OECD/CERI; **Italy**—Consiglio nazionale delle ricerche, unpublished tabulations (1997); **the Netherlands**—Department for Statistics of Education and Science, Netherlands Central Bureau of Statistics, unpublished tabulations (1997); **Portugal**—OECD/CERI; **Spain**—Estadisticas e Investigaciones Sociales, Instituto National de Estadistica, unpublished tabulations (1997), and OECD/CERI; **Sweden**—Statistics Sweden, unpublished tabulations (1997), and OECD/CERI; **United Kingdom**—Higher Education Statistics Agency, *Students in Higher Education Institutions: 1995/96* (Cheltenham: 1997); **EUROPEAN FREE TRADE ASSOCIATION: Norway**—Institute for Studies in Research and Higher Education, the Norwegian Research Council, unpublished tabulations (1997); **Switzerland**—Swiss Federal Statistical Office, unpublished tabulations (1997); **CENTRAL AND EASTERN EUROPE: Albania**—UNESCO (1996); **Bulgaria**—UNESCO (1996); **Czech Republic**—UNESCO (1996); Hungary—OECD/CERI; **Poland**—UNESCO (1996); **Romania**—UNESCO (1996); **Russia**—UNESCO (1996); **Slovak Republic**—UNESCO (1996); **Turkey**—UNESCO (1996); **NORTH AMERICA: Canada**—UNESCO (1996) and OECD/CERI; **Mexico**—Asociación Nacional de Universidades e Instituciones de Educación Superior, *Anuario Estadístico 1995: Posgrado* (Mexico: 1996); and **United States**—National Science Foundation, Science Resources Studies Division, *Science and Engineering Degrees 1966-94*, NSF 96-321 (Arlington, VA: 1996).

See figures 2-1, 2-2, and 2-4, and text table 2-1.

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Appendix table 2-2.

First university degrees in science and engineering awarded in selected Asian countries: 1975-95

	Six-country total	China	India[a]	Japan	Singapore	South Korea	Taiwan
All first university degrees							
1975	973,841	NA	NA	313,072	2,380	NA	29,053
1976	1,044,332	NA	629,336	326,167	2,388	34,725	29,053
1977	1,084,713	NA	651,999	339,819	2,357	37,374	29,685
1978	1,051,837	NA	675,478	356,981	2,422	41,447	30,740
1979	1,055,792	NA	620,247	374,887	2,763	45,964	32,383
1980	989,470	NA	599,795	378,666	2,645	50,973	34,223
1981	1,037,879	NA	522,963	386,057	2,187	56,528	32,214
1982	1,076,178	NA	560,893	382,466	2,395	62,688	33,341
1983	1,112,206	NA	595,288	369,069	2,905	77,272	34,507
1984	1,149,352	NA	628,453	372,247	3,725	90,888	35,714
1985	1,394,768	183,241	646,778	373,302	4,286	118,584	36,885
1986	1,464,453	207,405	678,470	376,260	4,818	137,848	38,567
1987	1,526,336	225,312	699,555	382,655	5,119	149,582	38,929
1988	1,579,580	249,337	724,739	382,828	5,227	161,983	40,205
1989	1,615,295	275,056	740,000	376,688	5,850	166,845	40,856
1990	1,638,655	273,684	750,000	400,103	6,000	165,916	42,952
1991	1,670,080	262,088	750,000	428,079	6,000	175,586	48,327
1992	1,725,220	298,438	750,000	437,878	5,897	178,632	54,375
1993	1,820,632	347,068	750,000	445,774	5,796	208,834	63,160
1994	1,774,418	310,291	750,000	461,898	5,697	183,372	63,160
1995	1,826,848	325,484	750,000	493,277	5,599	184,214	68,274
Natural sciences[b]							
1975	107,673	NA	95,382	7,014	466	3,111	1,700
1976	110,601	NA	98,038	7,483	490	2,713	1,877
1977	113,264	NA	100,768	7,479	335	2,889	1,793
1978	117,006	NA	103,574	7,985	347	3,165	1,935
1979	113,848	NA	99,724	8,248	528	3,468	1,880
1980	116,399	NA	101,455	8,636	573	3,800	1,935
1981	118,357	NA	103,217	8,651	460	4,164	1,866
1982	120,802	NA	105,008	8,710	577	4,562	1,945
1983	123,251	NA	106,831	8,575	663	5,202	1,980
1984	126,699	NA	108,686	9,054	726	6,241	1,992
1985	148,888	8,686	119,979	9,166	854	8,112	2,091
1986	151,327	9,336	122,550	9,435	945	6,913	2,148
1987	159,186	9,115	129,907	9,817	1,012	7,082	2,253
1988	158,975	8,045	130,000	9,895	982	7,673	2,380
1989	164,262	8,153	134,366	9,900	1,166	8,249	2,428
1990	168,941	7,802	139,000	9,866	1,278	8,514	2,481
1991	169,656	6,598	139,000	10,452	1,278	9,703	2,625
1992	170,852	5,580	139,000	10,386	1,281	11,828	2,777
1993	176,626	11,087	139,000	10,757	1,283	11,634	2,865
1994	202,887	36,726	139,000	11,476	1,286	11,443	2,956
1995	205,298	38,029	139,000	12,089	1,289	11,828	3,063

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Appendix table 2-2.

First university degrees in science and engineering awarded in selected Asian countries: 1975-95

	Six-country total	China	India[a]	Japan	Singapore	South Korea	Taiwan
			Mathematics and computer sciences				
1975	3,690	NA	NA	2,490	NA	NA	1,200
1976	4,263	NA	NA	2,529	NA	398	1,336
1977	4,506	NA	NA	2,755	NA	464	1,287
1978	4,496	NA	NA	2,703	NA	563	1,230
1979	4,857	NA	NA	2,829	NA	683	1,345
1980	5,168	NA	NA	2,918	NA	828	1,422
1981	5,595	NA	NA	3,152	NA	1,005	1,438
1982	5,974	NA	NA	3,045	NA	1,393	1,536
1983	6,447	NA	NA	3,148	NA	1,589	1,710
1984	6,808	NA	NA	3,180	NA	1,918	1,710
1985	16,100	7,764	NA	3,532	NA	2,888	1,916
1986	16,956	8,604	NA	3,379	NA	2,839	2,134
1987	17,777	8,974	NA	3,572	NA	3,149	2,082
1988	22,846	11,115	NA	3,493	NA	5,824	2,414
1989	25,369	13,079	NA	3,395	NA	6,274	2,621
1990	26,456	13,408	NA	3,554	NA	6,676	2,818
1991	28,239	13,847	NA	3,765	NA	7,547	3,080
1992	29,686	14,301	NA	3,790	NA	8,229	3,366
1993	29,097	12,520	NA	4,221	NA	8,502	3,854
1994	17,770	NA	NA	4,574	NA	8,784	4,412
1995	22,067	NA	NA	4,884	NA	12,351	4,832
			Agriculture				
1975	16,792	NA	3,966	9,480	NA	2,546	800
1976	18,166	NA	4,623	9,965	NA	2,680	898
1977	19,531	NA	5,388	10,455	NA	2,822	866
1978	21,149	NA	6,280	10,937	NA	2,971	961
1979	23,128	NA	6,280	12,794	NA	3,128	926
1980	22,051	NA	6,599	11,182	NA	3,293	977
1981	23,363	NA	6,934	11,555	NA	3,837	1,037
1982	23,805	NA	7,286	11,016	NA	4,493	1,010
1983	23,902	NA	7,656	10,658	NA	4,603	984
1984	24,520	NA	8,045	11,189	NA	4,327	959
1985	36,140	11,907	8,257	10,928	NA	4,068	980
1986	38,251	13,394	7,414	10,991	NA	5,483	969
1987	40,458	13,850	7,810	11,266	NA	6,395	1,137
1988	42,272	14,615	7,827	10,584	NA	8,050	1,196
1989	42,244	14,531	8,301	10,252	NA	8,027	1,133
1990	43,965	15,014	8,000	11,733	NA	8,005	1,234
1991	42,718	14,542	8,000	12,282	NA	6,586	1,272
1992	42,413	14,085	8,000	12,284	NA	6,628	1,311
1993	47,459	16,994	8,000	13,021	NA	7,843	1,561
1994	48,006	15,445	8,000	13,361	NA	9,281	1,859
1995	49,398	16,365	8,000	14,970	NA	7,767	2,236

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Appendix table 2-2.
First university degrees in science and engineering awarded in selected Asian countries: 1975-95

	Six-country total	China	India[a]	Japan	Singapore	South Korea	Taiwan
			Social sciences[c]				
1975	137,245	NA	NA	134,645	NA		2,600
1976	143,443	NA	NA	139,258	NA	1,423	2,762
1977	147,682	NA	NA	143,416	NA	1,379	2,887
1978	155,854	NA	NA	151,519	NA	1,452	2,883
1979	162,506	NA	NA	158,023	NA	1,528	2,955
1980	162,909	NA	NA	158,394	NA	1,609	2,906
1981	165,103	NA	NA	160,520	NA	1,694	2,889
1982	164,286	NA	NA	159,450	NA	1,783	3,053
1983	159,327	NA	NA	151,996	NA	4,297	3,034
1984	158,147	NA	NA	151,626	90	3,297	3,134
1985	174,750	13,855	NA	151,072	86	6,472	3,265
1986	178,441	16,515	NA	151,056	91	7,670	3,109
1987	182,845	19,619	NA	150,956	106	8,867	3,297
1988	186,578	22,707	NA	150,819	106	9,619	3,327
1989	186,159	27,713	NA	147,087	102	8,098	3,159
1990	199,707	28,728	NA	157,477	117	10,211	3,174
1991	225,221	32,163	NA	170,721	117	18,483	3,737
1992	236,131	36,009	NA	177,240	232	18,251	4,399
1993	233,751	31,656	NA	179,338	461	17,808	4,487
1994	239,078	29,622	NA	186,586	916	17,376	4,577
1995	256,573	32,075	NA	200,875	1,820	16,955	4,848
			Engineering				
1975	92,976	NA	14,073	66,512	236	7,155	5,000
1976	95,838	NA	15,057	68,126	241	7,272	5,142
1977	99,947	NA	16,110	70,431	290	7,858	5,258
1978	104,421	NA	17,237	72,466	240	8,919	5,559
1979	109,356	NA	17,236	75,409	272	10,124	6,315
1980	111,080	NA	18,100	74,737	288	11,492	6,463
1981	116,043	NA	19,007	76,370	323	13,044	7,299
1982	117,198	NA	19,959	74,774	349	14,806	7,309
1983	120,324	NA	20,960	70,824	585	20,636	7,320
1984	123,755	NA	22,010	71,640	585	22,190	7,330
1985	198,734	73,075	21,088	72,560	769	23,539	7,703
1986	214,434	79,556	24,096	74,516	924	27,612	7,730
1987	227,315	87,166	27,057	77,077	907	27,600	7,508
1988	241,800	101,411	27,000	77,503	1,001	26,891	7,994
1989	255,297	112,108	28,927	77,009	1,105	28,141	8,007
1990	257,325	108,729	29,000	81,355	1,220	28,071	8,950
1991	272,295	114,620	29,000	87,397	1,347	30,692	9,239
1992	280,975	120,830	29,000	88,385	1,423	31,800	9,537
1993	283,075	120,831	29,000	88,406	1,503	33,043	10,293
1994	308,867	141,654	29,000	91,184	1,587	34,334	11,108
1995	324,468	148,844	29,000	97,392	1,676	35,449	12,107

NA = not available

[a] Indian data are estimated for 1990-95.

[b] Natural sciences here include physical, earth, atmospheric, oceanographic, and biological sciences.

[c] Social sciences include psychology, sociology, and other social sciences. Japanese social science data also include business administration.

SOURCES: **China**—National Research Center for Science and Technology for Development, unpublished tabulations; **India**—Department of Science and Technology, *Research and Development Statistics 1994-95* (New Delhi:1996); **Japan**—Ministry of Education, Science, and Culture (Monbusho), *Monbusho Survey of Education* (Tokyo: annual series); **Singapore**—National University of Singapore, *Annual Report* (Singapore: 1996); **South Korea**—Ministry of Education, *Statistical Yearbook of Education* (Seoul: 1996). Organisation for Economic Co-operation and Development and Centre for Educational Research and Innovation, unpublished tabulations, and UNESCO (1996); and **Taiwan**—Ministry of Education, *Educational Statistics of the Republic of China* (Taipei: 1996).

Appendix table 2-3.
Population of 20- to 24-year-olds in selected countries/regions: 1975-2010
(Thousands)

	China	India	Western Europe	United States	Japan
1975	89,178	52,885	25,819	19,527	9,189
1976	88,370	54,634	26,075	19,922	8,916
1977	87,569	56,441	26,336	20,244	8,652
1978	86,776	58,308	26,602	20,505	8,395
1979	85,990	60,237	26,872	20,716	8,146
1980	85,211	62,229	27,146	21,584	7,904
1981	89,116	63,681	27,628	21,508	7,959
1982	93,201	65,167	28,121	21,433	8,015
1983	97,472	66,688	28,626	21,358	8,071
1984	101,940	68,244	29,143	21,283	8,127
1985	106,612	69,837	29,672	21,208	8,184
1986	110,434	71,349	29,575	20,700	8,329
1987	114,392	72,893	29,482	20,205	8,477
1988	118,493	74,470	29,391	19,721	8,628
1989	122,740	76,082	29,302	19,249	8,781
1990	127,140	77,729	29,356	18,788	8,937
1991	126,109	79,529	28,732	18,780	9,137
1992	125,086	81,372	28,096	18,771	9,342
1993	124,072	83,256	27,504	18,762	9,551
1994	123,066	85,185	26,937	17,853	9,765
1995	122,068	87,158	26,393	17,626	9,984
1996	116,094	87,594	25,824	17,501	9,664
1997	110,412	88,033	25,255	17,377	9,354
1998	105,008	88,473	24,686	17,254	9,054
1999	99,869	88,916	24,117	17,131	8,763
2000	94,981	89,361	23,548	17,010	8,482
2001	94,112	92,010	23,324	18,068	8,255
2002	93,251	94,738	23,100	18,292	8,035
2003	92,398	97,546	22,876	18,515	7,820
2004	91,553	100,438	22,652	18,739	7,611
2005	90,715	103,415	22,428	18,962	7,408
2006	95,379	104,983	25,482	19,038	7,282
2007	100,284	106,575	28,535	19,113	7,158
2008	105,440	108,190	31,589	19,189	7,036
2009	110,862	109,831	34,642	19,264	6,917
2010	116,562	111,496	37,696	19,340	6,799

SOURCES: U.S. Bureau of the Census, *Current Population Reports*, series P-25, Nos. 519 and 917; and World Bank, Population and Human Resources Department, *Population Projections, 1992-1993 Edition* (Washington, DC).

See figure 2-3.

Science & Engineering Indicators – 1998

Appendix table 2-4.
Percentage of 24-year-olds who earn first university degrees in S&E, by sex and region/country: Most recent year

Region/country	All first university degrees	Degree fields			24-year-olds			
		Natural sciences[a]	Social sciences[b]	Engineering	Total number	% with first univ. degree	% with NS&E degree	% with soc. sci. degree
				Males				
Asia								
Japan	334,227	22,536	163,517	91,078	1,023,200	32.7	11.1	16.0
South Korea	107,898	18,676	11,667	32,947	462,200	23.3	11.2	2.5
Taiwan	37,647	7,156	2,038	11,317	179,200	21.0	10.3	1.1
European Union								
Austria	6,530	1,189	370	1,069	57,775	11.3	3.9	0.6
Denmark	10,364	1,427	665	876	38,306	27.1	6.0	1.7
Finland	7,203	1,511	292	3,067	32,306	22.3	14.2	0.9
France	57,156	NA	NA	15,319	437,799	13.1	NA	NA
Germany	114,953	19,247	25,314	34,628	693,431	16.6	7.8	3.7
Greece	7,718	1,492	71	1,352	77,784	9.9	3.7	9.1
Ireland	6,712	1,347	433	1,339	33,135	20.3	8.1	1.3
Italy	47,863	6,662	3,944	8,075	457,580	10.5	3.2	0.9
The Netherlands	35,933	4,458	6,610	8,081	115,962	31.0	10.8	5.7
Portugal	8,538	748	902	1,804	83,440	10.2	3.1	1.1
Spain	60,521	8,026	1,688	9,016	338,120	17.9	5.0	0.5
Sweden	7,017	1,032	315	1,946	64,147	10.9	4.6	0.5
United Kingdom[c]	122,767	24,920	9,417	19,844	401,200	30.6	11.2	2.3
European Free Trade Association								
Norway	5,919	450	297	1,786	33,552	17.6	6.7	0.9
Switzerland	5,931	1,116	427	736	54,916	10.8	3.4	0.8
Central & Eastern Europe								
Czech Republic	10,054	1,501	1,196	4,244	80,019	12.6	7.2	1.5
Hungary	10,650	1,674	1,038	3,365	72,903	14.6	6.9	1.4
Poland	29,067	3,772	1,968	8,299	271,111	10.7	4.5	0.7
Turkey	45,557	5,227	8,140	8,010	583,346	7.8	2.3	1.4
North America								
Canada	52,728	7,625	9,835	6,616	193,759	27.2	7.3	5.1
United States	531,146	73,540	52,421	67,125	1,815,831	29.3	6.9	4.2
			Females					
Asia								
Japan	159,050	8,043	37,358	3,358	973,600	16.3	1.2	3.8
South Korea	66,088	11,229	4,100	6,314	428,600	15.4	4.1	1.0
Taiwan	30,627	2,975	2,810	790	169,200	18.1	2.2	1.7
European Union								
Austria	5,200	566	529	77	55,160	9.4	1.2	1.0
Denmark	13,042	2,714	871	237	36,992	35.3	8.0	2.4
Finland	6,919	636	515	477	30,868	22.4	3.6	1.7
France	63,086	NA	NA	3,994	418,116	15.1	NA	NA
Germany	82,120	10,261	20,949	3,989	661,435	12.4	2.2	3.2
Greece	10,838	1,078	150	433	74,038	14.6	2.0	0.2
Ireland	7,392	1,188	743	210	31,250	23.7	4.5	2.4
Italy	55,262	6,423	6,481	941	439,668	12.6	1.7	1.5
The Netherlands	33,235	1,427	7,653	1,422	112,539	29.5	2.5	6.8
Portugal	13,964	1,011	1,744	664	80,759	17.3	2.1	2.2
Spain	77,302	5,778	4,026	1,801	321,199	24.1	2.4	1.3
Sweden	8,753	620	997	558	60,420	14.5	1.9	1.7
United Kingdom[c]	128,481	18,517	11,744	3,474	382,600	33.6	5.7	3.1
European Free Trade Association								
Norway	13,104	175	168	466	33,800	38.8	1.9	0.5
Switzerland	3,272	376	495	26	54,319	6.0	0.7	0.9
Central & Eastern Europe								
Czech Republic	9,512	852	1,845	1,316	74,009	12.9	2.9	2.5
Hungary	12,965	766	1,693	790	68,431	18.9	2.3	2.5
Poland	31,157	4,014	2,972	1,381	256,888	12.1	2.1	1.2
Turkey	27,025	4,007	4,374	2,063	560,849	4.8	1.1	0.8
North America								
Canada	70,474	5,533	14,742	1,122	187,243	37.6	3.6	7.9
United States	643,290	55,925	109,056	10,950	1,750,926	36.7	3.8	6.2

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Appendix table 2-4.
Percentage of 24-year-olds who earn first university degrees in S&E, by sex and region/country: Most recent year

NA = not available; NS&E = natural sciences and engineering

NOTES: Data from European countries combine short (three-year) and long (four- to six-year) degree programs. Data are compiled from numerous national and international sources, and degree fields may not be strictly comparable. First university degrees in different countries are of different duration and may not be academically equivalent. U.K. data are for 1996. Data for Japan, South Korea, Taiwan, Austria, Switzerland, and the United States are for 1995. Data for Finland, France, Germany, Italy, Portugal, Sweden, Norway, Czech Republic, and Canada are for 1994. Data for Denmark, Greece, Ireland, the Netherlands, Spain, Hungary, Poland, and Turkey are for 1993.

[a] Natural sciences here include physical, earth, atmospheric, oceanographic, biological, and agricultural, as well as mathematics and computer sciences.

[b] Social sciences include psychology, sociology, and other social sciences. Japanese social science data also include business administration.

[c] U.K. data include former colleges and polytechnics.

SOURCES: **ASIA: Japan**—Ministry of Education, Science, and Culture (Monbusho), *Monbusho Survey of Education* (Tokyo: annual series); **South Korea**—Ministry of Education, *Statistical Yearbook of Education* (Seoul: 1996); **Taiwan**—Ministry of Education, *Educational Statistics of the Republic of China* (Taipei: 1996); **EUROPEAN UNION: Austria**—Austrian Central Statistical Office, unpublished tabulations; **Denmark**—Department of Higher Education, Ministry of Education, unpublished tabulations (1997); **Finland**—Central Statistical Office, unpublished tabulations (1997), and Organisation for Economic Co-operation and Development and Centre for Educational Research and Innovation (OECD/CERI), unpublished tabluations; **France**—Ministère de l'Éducation Nationale, *Repères et Références Statistiques sur les Enseignements et la Formation* (Vanves, France: 1996); **Germany**—Statistisches Bundesamt Wiesbaden, *Prüfungen an Hochschulen* (Wiesbaden: 1996); **Greece**—National Statistical Service of Greece, unpublished tabulations (1997), and OECD/CERI; **Ireland**—OECD/CERI; Italy—Consiglio nazionale delle ricerche, unpublished tabulations (1997); **the Netherlands**—Department for Statistics of Education and Science, Netherlands Central Bureau of Statistics, unpublished tabulations (1997); **Portugal**—OECD/CERI; **Spain**—Estadisticas e Investigaciones Sociales, Instituto National de Estadistica, unpublished tabulations (1997), and OECD/CERI; **Sweden**—Statistics Sweden, unpublished tabulations (1997), and OECD/CERI; **United Kingdom**—Higher Education Statistics Agency, *Students in Higher Education Institutions: 1995/96* (Cheltenham: 1997); **EUROPEAN FREE TRADE ASSOCIATION: Norway**—Institute for Studies in Research and Higher Education, the Norwegian Research Council, unpublished tabulations (1997); **Switzerland**—Swiss Federal Statistical Office, unpublished tabulations (1997); **CENTRAL AND EASTERN EUROPE: Czech Republic**—UNESCO (1996); **Hungary**—OECD/CERI; **Poland**—UNESCO (1996); **Turkey**—UNESCO (1996); **NORTH AMERICA: Canada**—UNESCO (1996) and OECD/CERI; and **United States**—National Science Foundation, Science Resources Studies Division, *Science and Engineering Degrees 1966-94*, NSF 96-321 (Arlington, VA: 1996).

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Appendix table 2-5.
Share of first university S&E degrees, by sex and country: Most recent year
(Percentages)

Region/country	Natural sciences[a]	Math & comp. sciences	Agricultural sciences	Social sciences[b]	Engineering
		Males			
Asia					
Japan	79	77	68	81	94
South Korea	56	60	63	73	93
Taiwan	73	71	66	42	93
European Union					
Austria	63	78	60	41	94
Denmark	69	16	67	43	79
Finland	49	87	63	36	87
France	NA	63	NA	NA	80
Germany	64	69	60	55	90
Greece	57	58	62	32	76
Ireland	46	63	68	37	86
Italy	46	51	66	38	90
The Netherlands	66	11	77	46	85
Portugal	36	45	47	34	73
Spain	53	67	52	30	83
Sweden	47	77	50	24	78
United Kingdom[c]	50	73	49	46	85
European Free Trade Assoc.					
Norway	54	84	78	43	82
Switzerland	72	88	63	40	93
Central & Eastern Europe					
Czech Republic	47	77	64	39	76
Hungary	66		69	38	81
Poland	33	32	62	40	86
Turkey	50	53	65	65	80
North America					
Canada	52	70	47	40	86
United States	53	65	65	45	85
		Females			
Asia					
Japan	21	23	32	19	6
South Korea	44	40	37	27	7
Taiwan	27	29	34	58	7
European Union					
Austria	37	22	40	59	6
Denmark	31	84	33	57	21
Finland	51	13	37	64	13
France	NA	37	NA	NA	20
Germany	36	31	40	45	10
Greece	43	42	38	68	24
Ireland	54	37	32	63	14
Italy	54	49	34	62	10
The Netherlands	34	89	23	54	15
Portugal	64	55	53	66	27
Spain	47	33	48	70	17
Sweden	53	23	50	76	22
United Kingdom[c]	50	27	51	55	15
European Free Trade Assoc.					
Norway	46	16	22	57	18
Switzerland	28	12	37	60	7
Central & Eastern Europe					
Czech Republic	53	23	36	61	24
Hungary	34		31	62	19
Poland	67	68	38	60	14
Turkey	50	47	35	35	20
North America					
Canada	48	30	53	60	14
United States	47	35	35	55	15

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Appendix table 2-5.

Share of first university S&E degrees, by sex and country: Most recent year

(Percentages)

NA = not available

NOTES: Data from European countries combine short (three-year) and long (four- to six-year) degree programs. Data are compiled from numerous national and international sources, and degree fields may not be strictly comparable. First university degrees in different countries are of different duration and may not be academically equivalent. U.K. data are for 1996. Data for Japan, South Korea, Taiwan, Austria, Switzerland, and the United States are for 1995. Data for Finland, France, Germany, Italy, Portugal, Sweden, Norway, Czech Republic, and Canada are for 1994. Data for Denmark, Greece, Ireland, the Netherlands, Spain, Hungary, Poland, and Turkey are for 1993.

[a] Natural sciences here include physical, earth, atmospheric, oceanographic, and biological sciences.

[b] Social sciences include psychology, sociology, and other social sciences. Japanese social science data also include business administration.

[c] U.K. data include former colleges and polytechnics.

SOURCES: **ASIA: Japan**—Ministry of Education, Science, and Culture (Monbusho), *Monbusho Survey of Education* (Tokyo: annual series); **South Korea**—Ministry of Education, *Statistical Yearbook of Education* (Seoul: 1996); **Taiwan**—Ministry of Education, *Educational Statistics of the Republic of China* (Taipei: 1996); **EUROPEAN UNION: Austria**—Austrian Central Statistical Office, unpublished tabulations; **Denmark**—Department of Higher Education, Ministry of Education, unpublished tabulations (1997); **Finland**—Central Statistical Office, unpublished tabulations (1997), and Organisation for Economic Co-operation and Development and Centre for Educational Research and Innovation (OECD/CERI), unpublished tabluations; **France**—Ministère de l'Éducation Nationale, *Repères et Références Statistiques sur les Enseignements et la Formation* (Vanves, France: 1996); **Germany**—Statistisches Bundesamt Wiesbaden, *Prüfungen an Hochschulen* (Wiesbaden: 1996); **Greece**—National Statistical Service of Greece, unpublished tabulations (1997), and OECD/CERI; **Ireland**—OECD/CERI; **Italy**—Consiglio nazionale delle ricerche, unpublished tabulations (1997); **the Netherlands**—Department for Statistics of Education and Science, Netherlands Central Bureau of Statistics, unpublished tabulations (1997); **Portugal**—OECD/CERI; **Spain**—Estadisticas e Investigaciones Sociales, Instituto National de Estadistica, unpublished tabulations (1997) and OECD/CERI; **Sweden**—Statistics Sweden, unpublished tabulations (1997), and OECD/CERI; **United Kingdom**—Higher Education Statistics Agency, *Students in Higher Education Institutions: 1995/96* (Cheltenham: 1997); **EUROPEAN FREE TRADE ASSOCIATION: Norway**—Institute for Studies in Research and Higher Education, the Norwegian Research Council, unpublished tabulations (1997); **Switzerland**—Swiss Federal Statistical Office, unpublished tabulations (1997); **CENTRAL AND EASTERN EUROPE: Czech Republic**—UNESCO (1996); **Hungary**—OECD/CERI; **Poland**—UNESCO (1996); **Turkey**—UNESCO (1996); **NORTH AMERICA: Canada**—UNESCO (1996) and OECD/CERI; and **United States**—National Science Foundation, Science Resources Studies Division, *Science and Engineering Degrees 1966-94*, NSF 96-321 (Arlington, VA: 1996).

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Appendix table 2-6.

Proportion of first university degrees awarded in S&E, by region/country: Most recent year

(Percentages)

Region/country	Total first univ. degrees	Total S&E	Degree fields: Natural sciences[a]	Degree fields: Social sciences[b]	Degree fields: Engineering	Degree fields: Non-S&E
Asia						
China	100	72	17	10	46	28
Hong Kong	100	48	21	11	16	52
India	100	23	20	NA	4	77
Indonesia	100	44	14	18	12	56
Japan	100	67	6	41	20	33
Malaysia	100	45	16	21	8	55
Singapore	100	100	38	33	30	0
South Korea	100	46	17	9	19	54
Taiwan	100	40	15	7	18	60
Thailand	100	21	9	6	6	79
Europe						
European Union						
Austria	100	34	16	8	10	66
Belgium	100	57	9	26	22	43
Denmark	100	29	7	7	15	71
Finland	100	46	15	6	25	54
France	100	32	16	NA	16	68
Germany	100	46	16	9	21	54
Greece	100	25	14	1	10	75
Ireland	100	37	18	8	11	63
Italy	100	32	13	10	9	68
The Netherlands	100	39	7	17	15	61
Portugal	100	31	8	12	11	69
Spain	100	26	14	7	5	74
Sweden	100	35	10	8	16	65
United Kingdom[c]	100	35	17	8	9	65
European Free Trade Association						
Norway	100	24	5	4	14	76
Switzerland	100	39	10	11	18	61
Central & Eastern Europe						
Albania	100	40	23	4	13	60
Bulgaria	100	38	9	2	27	62
Czech Republic	100	42	12	2	28	58
Hungary	100	39	10	12	18	61
Poland	100	37	13	8	16	63
Romania	100	60	12	1	47	40
Russia	100	57	29	7	20	43
Slovak Republic	100	46	11	1	33	54
Turkey	100	46	13	21	13	54
North America						
Canada	100	33	10	18	6	67
Mexico	100	47	7	9	31	53
United States	100	32	10	16	5	68

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Appendix table 2-6.
Proportion of first university degrees awarded in S&E, by region/country: Most recent year
(Percentages)

NA = not available

NOTES: Data from European countries combine short (three-year) and long (four- to six-year) degree programs. Data are compiled from numerous national and international sources, and degree fields may not be strictly comparable. U.K. data are for 1996. Data for China, Japan, Singapore, South Korea, Taiwan, Austria, Switzerland, and the United States are for 1995. Data for Finland, France, Germany, Italy, Portugal, Sweden, Norway, Bulgaria, Czech Republic, Russia, Slovakia, Canada, and Mexico are for 1994. Data for Hong Kong, Belgium, Denmark, Greece, Ireland, the Netherlands, Spain, Albania, Hungary, Poland, Romania, and Turkey are for 1993. Data for Indonesia and Thailand are for 1992. Indian and Malaysian data are for 1990.

[a] Natural sciences here include physical, earth, atmospheric, oceanographic, biological, and agricultural, as well as mathematics and computer sciences.

[b] Social sciences include psychology, sociology, and other social sciences. Japanese social science data also include business administration. Mexican social science data are estimated.

[c] U.K. data include former colleges and polytechnics.

SOURCES: **ASIA: China**—National Research Center for Science and Technology for Development, unpublished tabulations, and UNESCO, *Statistical Yearbook* (Paris: 1996); **Hong Kong**—UNESCO (1996); **India**—Department of Science and Technology, *Research and Development Statistics 1994-95* (New Delhi: 1996); **Indonesia**—UNESCO (1996); **Japan**—Ministry of Education, Science, and Culture (Monbusho), *Monbusho Survey of Education* (Tokyo: annual series); **Malaysia**—UNESCO (1996); **Singapore**—National University of Singapore, *Annual Report* (Singapore: 1996); **South Korea**—Ministry of Education, *Statistical Yearbook of Education, 1996* (Seoul: 1996); **Taiwan**—Ministry of Education, *Educational Statistics of the Republic of China* (Taipei: 1996); **Thailand**—UNESCO (1996); **EUROPEAN UNION: Austria**—Austrian Central Statistical Office, unpublished tabulations; **Belgium**—Organisation for Economic Co-operation and Development and Centre for Educational Research and Innovation (OECD/CERI), unpublished tabulations, and UNESCO (1996) (social sciences); **Denmark**—Department of Higher Education, Ministry of Education, unpublished tabulations (1997); **Finland**—Central Statistical Office, unpublished tabulations (1997), and OECD/CERI; **France**—Ministère de l'Éducation Nationale, *Repères et Références Statistiques sur les Enseignements et la Formation* (Vanves, France: 1996); **Germany**—Statistisches Bundesamt Wiesbaden, *Prüfungen an Hochschulen* (Wiesbaden: 1996); **Greece**—National Statistical Service of Greece, unpublished tabulations (1997), and OECD/CERI; **Ireland**—OECD/CERI; **Italy**—Consiglio nazionale delle ricerche, unpublished tabulations (1997); **the Netherlands**—Department for Statistics of Education and Science, Netherlands Central Bureau of Statistics, unpublished tabulations (1997); **Portugal**—OECD/CERI; **Spain**—Estadisticas e Investigaciones Sociales, Instituto National de Estadistica, unpublished tabulations (1997) and OECD/CERI; **Sweden**—Statistics Sweden, unpublished tabulations (1997), and OECD/CERI; **United Kingdom**—Higher Education Statistics Agency, *Students in Higher Education Institutions: 1995/96* (Cheltenham: 1997); **EUROPEAN FREE TRADE ASSOCIATION: Norway**—Institute for Studies in Research and Higher Education, the Norwegian Research Council, unpublished tabulations (1997); **Switzerland**—Swiss Federal Statistical Office, unpublished tabulations (1997); **CENTRAL AND EASTERN EUROPE: Albania**—UNESCO (1996); **Bulgaria**—UNESCO (1996); **Czech Republic**—UNESCO (1996); Hungary—OECD/CERI; **Poland**—UNESCO (1996); **Romania**—UNESCO (1996); **Russia**—UNESCO (1996); **Slovak Republic**—UNESCO (1996); **Turkey**—UNESCO (1996); **NORTH AMERICA: Canada**—UNESCO (1996) and OECD/CERI; **Mexico**—Asociación Nacional de Universidades e Instituciones de Educación Superior, *Anuario Estadístico 1995: Posgrado* (Mexico: 1996); and **United States**—National Science Foundation, Science Resources Studies Division, *Science and Engineering Degrees 1966-94*, NSF 96-321 (Arlington, VA: 1996).

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Appendix table 2-7.

Proportion of first university degrees awarded in S&E, by sex and region/country: Most recent year
(Percentages)

Region/country	Total first univ. degrees	Total S&E	Degree fields			
			Natural sciences[a]	Social sciences[b]	Engineering	Non-S&E
			Males			
Asia						
Japan	100	83	7	49	27	17
South Korea	100	59	17	11	31	41
Taiwan	100	54	19	5	30	46
European Union						
Austria	100	40	18	6	16	60
Denmark	100	29	14	6	8	71
Finland	100	68	21	4	43	32
Germany	100	69	17	22	30	31
Greece	100	38	19	1	18	62
Ireland	100	46	20	6	20	54
Italy	100	39	14	8	17	61
The Netherlands	100	53	12	18	22	47
Portugal	100	40	9	11	21	60
Spain	100	31	13	3	15	69
Sweden	100	47	15	4	28	53
United Kingdom[c]	100	44	20	8	16	56
European Free Trade Association						
Norway	100	43	8	5	30	57
Switzerland	100	38	19	7	12	62
Central & Eastern Europe						
Czech Republic	100	69	15	12	42	31
Hungary	100	57	16	10	32	43
Poland	100	48	13	7	29	52
Turkey	100	47	11	18	18	53
North America						
Canada	100	46	14	19	13	54
United States	100	43	13	17	12	57
			Females			
Asia						
Japan	100	31	5	23	2	69
South Korea	100	33	17	6	10	67
Taiwan	100	21	10	9	3	79
European Union						
Austria	100	23	11	10	1	77
Denmark	100	29	21	7	2	71
Finland	100	24	9	7	7	76
Germany	100	43	12	26	5	57
Greece	100	15	10	1	4	85
Ireland	100	29	16	10	3	71
Italy	100	25	12	12	2	75
The Netherlands	100	32	4	23	4	68
Portugal	100	24	7	12	5	76
Spain	100	15	7	5	2	85
Sweden	100	25	7	11	6	75
United Kingdom[c]	100	26	14	9	3	74
European Free Trade Association						
Norway	100	6	1	1	4	94
Switzerland	100	27	11	15	1	73
Central & Eastern Europe						
Czech Republic	100	42	9	19	14	58
Hungary	100	25	6	13	6	75
Poland	100	27	13	10	4	73
Turkey	100	39	15	16	8	61
North America						
Canada	100	43	13	17	12	57
United States	100	27	8	18	2	73

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Appendix table 2-7.

Proportion of first university degrees awarded in S&E, by sex and region/country: Most recent year

(Percentages)

NA = not available

NOTES: Data from European countries combine short (three-year) and long (four- to six-year) degree programs. Data are compiled from numerous national and international sources, and degree fields may not be strictly comparable. U.K. data are for 1996. Data for Japan, South Korea, Taiwan, Austria, Switzerland, and the United States are for 1995. Data for Finland, Germany, Italy, Portugal, Sweden, Norway, Czech Republic, and Canada are for 1994. Data for Denmark, Greece, Ireland, the Netherlands, Spain, Hungary, Poland, and Turkey are for 1993.

[a] Natural sciences here include physical,earth, atmospheric, oceanographic, biological, and agricultural, as well as mathematics and computer sciences.

[b] Social sciences include psychology, sociology, and other social sciences. Japanese social science data also include business administration.

[c] U.K. data include former colleges and polytechnics.

SOURCES: ASIA: **Japan**—Ministry of Education, Science, and Culture (Monbusho), *Monbusho Survey of Education* (Tokyo: annual series); **South Korea**—Ministry of Education, *Statistical Yearbook of Education* (Seoul: 1996); **Taiwan**—Ministry of Education, *Educational Statistics of the Republic of China* (Taipei: 1996); **EUROPEAN UNION: Austria**—Austrian Central Statistical Office, unpublished tabulations; **Denmark**—Department of Higher Education, Ministry of Education, unpublished tabulations (1997); **Finland**—Central Statistical Office, unpublished tabulations (1997), and Organisation for Economic Co-operation and Development and Centre for Educational Research and Innovation (OECD/CERI); **Germany**—Statistisches Bundesamt Wiesbaden, *Prüfungen an Hochschulen* (Wiesbaden: 1996); **Greece**—National Statistical Service of Greece, unpublished tabulations (1997), and OECD/CERI; **Ireland**—OECD/CERI; **Italy**—Consiglio nazionale delle ricerche, unpublished tabulations (1997); **the Netherlands**—Department for Statistics of Education and Science, Netherlands Central Bureau of Statistics, unpublished tabulations (1997); **Portugal**—OECD/CERI; **Spain**—Estadisticas e Investigaciones Sociales, Instituto National de Estadistica, unpublished tabulations (1997) and OECD/CERI; **Sweden**—Statistics Sweden, unpublished tabulations (1997), and OECD/CERI; **United Kingdom**—Higher Education Statistics Agency, *Students in Higher Education Institutions: 1995/96* (Cheltenham: 1997); **EUROPEAN FREE TRADE ASSOCIATION: Norway**—Institute for Studies in Research and Higher Education, the Norwegian Research Council, unpublished tabulations (1997); **Switzerland**—Swiss Federal Statistical Office, unpublished tabulations (1997); **CENTRAL AND EASTERN EUROPE: Czech Republic**—UNESCO (1996); **Hungary**—OECD/CERI; **Poland**—UNESCO, *Statistical Yearbook* (Paris: 1996); **Turkey**—UNESCO (1996); **NORTH AMERICA: Canada**—UNESCO (1996) and OECD/CERI; and **United States**—National Science Foundation, Science Resources Studies Division, *Science and Engineering Degrees 1966-94*, NSF 96-321 (Arlington, VA: 1996).

Appendix table 2-8.

Enrollment in higher education, by Carnegie institution type: 1967-94

	Total	Research I	Research II	Doctorate-granting I	Doctorate-granting II	Comprehensive I	Comprehensive II	Liberal arts I	Liberal arts II	Two-year	Specialized	Other	Not classified
1967	6,963,687	1,510,037	494,527	437,195	354,542	1,661,186	109,412	203,663	411,819	1,426,223	179,824	26,108	149,151
1968	7,571,636	1,564,981	517,844	455,455	389,249	1,813,749	119,881	209,398	431,621	1,709,796	187,216	27,560	144,886
1969	8,066,233	1,644,645	538,934	483,378	410,395	1,935,316	127,467	215,618	443,108	1,912,663	196,120	29,914	128,675
1970	8,649,368	1,748,776	570,365	509,450	436,660	2,071,472	137,127	221,996	452,087	2,180,252	209,689	32,862	78,632
1971	9,025,031	1,717,735	577,538	519,572	457,251	2,160,655	143,124	228,947	464,590	2,435,108	219,362	35,281	65,868
1972	9,297,787	1,768,282	581,139	521,856	466,371	2,183,621	142,270	233,939	464,218	2,609,721	229,938	31,451	64,981
1973	9,694,297	1,771,632	592,051	526,349	479,905	2,249,865	141,812	236,910	477,097	2,872,230	250,810	36,007	59,629
1974	10,321,539	1,826,768	612,510	545,772	497,963	2,324,124	153,182	238,868	494,426	3,272,215	271,148	34,553	50,010
1975	11,290,719	1,921,415	642,703	560,827	532,135	2,464,953	163,672	240,097	541,017	3,837,843	304,401	35,149	46,507
1976	11,121,426	1,893,269	613,142	568,570	526,247	2,415,834	168,445	240,730	551,890	3,755,311	307,760	33,066	47,162
1977	11,418,631	1,877,142	619,941	579,896	543,360	2,474,300	174,612	243,738	573,678	3,926,266	322,060	35,077	48,561
1978	11,393,015	1,864,590	626,213	581,343	542,558	2,452,812	178,964	251,607	579,494	3,910,980	334,133	34,665	35,656
1979	11,707,126	1,903,347	639,287	594,589	547,418	2,462,361	183,554	251,231	603,830	4,103,418	349,810	34,984	33,297
1980	12,234,644	1,947,444	655,874	604,769	570,666	2,531,409	188,971	260,645	633,712	4,404,276	371,265	35,861	29,752
1981	12,517,753	1,961,015	659,114	610,640	578,653	2,564,542	197,462	257,592	644,924	4,598,599	382,729	37,109	25,374
1982	12,588,520	1,933,340	650,946	606,683	582,638	2,570,690	200,403	252,029	651,192	4,671,136	398,091	37,800	33,572
1983	12,633,930	1,957,038	648,369	612,818	589,126	2,592,710	205,689	254,700	668,374	4,640,343	408,837	39,412	16,514
1984	12,400,392	1,952,748	644,056	604,742	591,400	2,576,072	203,725	253,604	656,099	4,456,709	410,765	38,571	11,901
1985	12,411,945	1,959,685	641,723	603,961	589,103	2,589,406	208,603	254,972	656,146	4,452,391	406,794	38,467	10,694
1986	12,670,121	1,988,839	653,298	609,772	590,694	2,629,336	210,267	257,998	657,695	4,598,068	409,389	39,097	25,668
1987	12,925,116	2,013,832	664,997	619,854	601,073	2,675,959	219,167	262,649	665,726	4,736,425	404,257	41,729	19,448
1988	13,205,540	2,029,065	685,731	631,073	608,663	2,738,439	227,937	269,151	693,086	4,840,892	422,184	39,953	19,366
1989	13,621,203	2,046,868	704,842	644,062	623,988	2,831,502	238,431	266,907	716,902	5,069,469	419,901	40,260	18,071
1990	13,871,725	2,078,969	714,180	656,807	634,551	2,882,708	243,690	268,223	730,455	5,145,123	440,214	40,728	36,077
1991	14,527,724	2,094,841	720,127	660,908	643,519	2,961,425	255,272	268,960	757,093	5,590,543	454,819	44,370	75,847
1992	14,657,118	2,089,045	714,126	655,985	649,549	2,962,204	259,253	266,735	781,168	5,658,832	477,202	46,560	96,459
1993	14,477,792	2,078,622	701,058	648,068	644,533	2,941,741	261,163	264,222	791,081	5,498,797	489,342	47,936	111,229
1994	14,449,476	2,079,559	694,454	639,831	650,816	2,924,462	266,854	264,737	797,088	5,442,459	496,522	48,725	143,969
1995	14,432,145	2,080,163	691,292	638,157	659,197	2,921,613	265,523	267,327	809,443	5,406,744	496,508	48,878	147,300

SOURCES: National Center for Education Statistics, Enrollment Survey (Washington, DC: 1995); and National Science Foundation, Science Resources Studies Division, unpublished tabulations.

Science & Engineering Indicators – 1998

See figures 2-5 and 2-6.

Appendix table 2-9.

Number of science and engineering degrees, by degree level and institution type: 1995

Institution type	Total degrees	Total S&E	Natural sciences[a]	Math & computer sciences	Social sciences[b]	Engineering	Engineering technology[c]
			Bachelor's degrees				
Total	1,174,436	378,148	90,845	38,620	185,312	63,371	16,607
Research I	277,600	125,652	31,638	8,006	55,994	30,014	1,631
Research II	94,638	34,672	8,116	2,236	16,155	8,165	1,194
Doctorate-granting I	81,634	23,697	4,865	2,433	12,513	3,886	1,128
Doctorate-granting II	78,568	27,154	5,319	2,836	12,224	6,775	1,044
Comprehensive I	386,961	100,486	23,782	13,633	53,236	9,835	6,347
Comprehensive II	36,300	8,196	1,886	1,364	4,635	311	708
Liberal arts I	52,036	25,523	7,758	1,738	15,567	460	0
Liberal arts II	114,318	25,156	6,501	4,171	13,474	1,010	1,778
Two-year	1,707	146	50	20	56	20	447
Specialized	43,892	4,779	593	2,008	308	1,870	2,211
Other	4,858	2,477	328	157	967	1,025	17
Not classified	1,924	210	9	18	183	0	102
			Master's degrees				
Total	399,428	94,309	14,793	14,495	36,391	28,630	1,577
Research I	122,809	39,502	7,206	5,054	11,916	15,326	382
Research II	33,115	10,916	1,799	1,359	3,556	4,202	34
Doctorate-granting I	39,557	9,025	1,192	1,896	3,691	2,246	169
Doctorate-granting II	30,319	8,726	1,416	1,640	2,902	2,768	102
Comprehensive I	133,128	20,486	2,441	3,844	11,047	3,154	711
Comprehensive II	6,707	519	42	71	366	40	37
Liberal arts I	4,779	1,016	148	22	800	46	0
Liberal arts II	3,624	463	47	8	392	16	28
Specialized	20,708	2,038	465	522	405	646	63
Other	3,917	1,552	37	65	1,264	186	51
Not classified	765	66	0	14	52	0	0
			Doctoral degrees				
Total	44,513	25,921	10,219	2,069	7,521	6,112	19
Research I	28,548	17,837	7,504	1,536	4,111	4,686	7
Research II	5,034	2,874	1,161	235	775	703	0
Doctorate-granting I	4,633	2,199	505	194	1,169	331	0
Doctorate-granting II	2,101	1,261	442	95	417	307	0
Comprehensive I	723	224	47	0	132	45	12
Comprehensive II	12	12	3	0	9	0	0
Liberal arts I	167	49	18	5	26	0	0
Liberal arts II	42	15	0	0	15	0	0
Specialized	2,241	641	538	2	68	33	0
Other	985	809	1	2	799	7	0
Not classified	27	0	0	0	0	0	0

[a] Natural sciences here include physical, earth, atmospheric, oceanographic, biological, and agricultural sciences.

[b] Social sciences include psychology, sociology, and other social sciences.

[c] Engineering technology data are not included in "Total S&E."

SOURCES: National Center for Education Statistics, Completion Survey (Washington, DC: 1995); and National Science Foundation, Science Resources Studies Division, unpublished tabulations.

See figures 2-5 and 2-7.

Science & Engineering Indicators – 1998

Appendix table 2-10.

Number of institutions awarding science and engineering degrees, by degree level and institution type: 1995

Institution type	Total institutions	Total S&E	Natural sciences[a]	Math & computer sciences	Social sciences[b]	Engineering	Engineering technology[c]
			Bachelor's degrees				
Total	1,810	1,457	1,286	1,296	1,355	398	346
Research I	88	87	87	86	86	78	21
Research II	38	38	38	38	38	34	15
Doctorate-granting I	49	48	45	46	48	24	16
Doctorate-granting II	59	58	58	57	56	40	21
Comprehensive I	438	433	416	421	430	127	155
Comprehensive II	93	93	87	83	91	15	18
Liberal arts I	163	157	153	149	157	21	0
Liberal arts II	462	440	374	362	410	34	59
Two-year	44	11	1	4	5	1	11
Specialized	352	77	18	44	23	18	28
Other	18	13	8	4	10	6	1
Not classified	6	2	1	2	1	0	1
			Master's degrees				
Total	1,312	746	474	434	611	265	78
Research I	87	87	87	84	87	79	11
Research II	38	38	38	38	38	33	4
Doctorate-granting I	49	49	46	44	46	20	8
Doctorate-granting II	59	59	55	49	52	36	6
Comprehensive I	437	345	191	187	291	71	40
Comprehensive II	92	28	6	5	17	2	2
Liberal arts I	58	24	11	7	18	2	0
Liberal arts II	158	24	5	1	19	2	2
Specialized	301	69	33	16	20	18	4
Other	31	22	2	2	22	2	1
Not classified	2	1	0	1	1	0	0
			Doctoral degrees				
Total	479	329	257	171	258	170	4
Research I	88	88	88	81	87	78	2
Research II	38	38	38	36	36	32	0
Doctorate-granting I	50	50	37	28	48	18	0
Doctorate-granting II	59	56	44	23	39	27	0
Comprehensive I	74	30	13	0	15	8	2
Comprehensive II	2	2	1	0	1	0	0
Liberal arts I	11	5	2	1	4	0	0
Liberal arts II	4	1	0	0	1	0	0
Specialized	127	39	33	1	8	6	0
Other	25	20	1	1	19	1	0
Not classified	1	0	0	0	0	0	0

[a] Natural sciences here include physical, earth, atmospheric, oceanographic, biological, and agricultural sciences.

[b] Social sciences include psychology, sociology, and other social sciences.

[c] Engineering technology data are not included in "Total S&E."

SOURCES: National Center for Education Statistics, Completion Survey (Washington, DC: 1995); and National Science Foundation, Science Resources Studies Division, unpublished tabulations.

See figure 2-5.

Science & Engineering Indicators – 1998

Appendix table 2-11.

Total undergraduate enrollment, by race/ethnicity, citizenship, and sex: 1978-95

Race/ethnicity and citizenship	1978	1980	1982	1984	1986	1988	1990	1992	1993	1994	1995
					All students						
Total	9,808,815	9,821,513	10,205,475	10,081,336	10,952,167	11,453,788	12,011,657	12,693,778	12,482,813	12,417,701	12,399,826
White	7,872,635	7,827,035	8,060,213	7,635,957	8,406,100	8,737,576	9,232,090	9,388,226	9,101,085	8,905,614	8,806,202
Asian	206,065	225,422	280,062	296,123	384,004	431,053	491,134	620,463	642,893	683,131	700,828
Black	968,059	968,481	956,510	860,322	982,214	1,002,515	1,125,591	1,282,732	1,292,621	1,319,262	1,336,052
Hispanic	501,053	523,021	582,726	547,837	691,621	741,814	840,370	1,032,817	1,064,348	1,120,929	1,167,472
Native American	71,891	70,553	74,123	66,120	81,356	84,108	95,135	110,879	112,727	117,856	120,728
Foreign citizen	170,517	201,034	212,999	200,146	199,921	202,815	227,337	258,661	269,139	270,909	268,544
					Males						
Total	4,814,322	4,723,979	4,910,480	4,787,658	5,078,768	5,192,254	5,396,557	5,644,113	5,547,126	5,484,342	5,467,370
White	3,884,778	3,785,209	3,881,826	3,635,294	3,908,642	3,979,958	4,165,862	4,195,726	4,067,289	3,958,270	3,918,342
Asian	108,261	117,574	148,969	156,947	201,591	221,673	250,287	308,564	318,289	335,737	342,084
Black	416,816	407,497	400,746	352,703	396,749	395,359	440,209	496,123	500,194	503,381	507,380
Hispanic	244,149	244,444	270,386	250,043	313,108	329,866	371,232	453,488	467,155	490,827	505,162
Native American	33,481	31,621	33,589	29,498	35,592	35,501	39,692	46,572	47,233	48,920	50,223
Foreign citizen	116,583	134,864	143,000	132,496	127,364	122,320	129,275	143,640	146,966	147,207	144,179
					Females						
Total	4,994,493	5,097,534	5,294,995	5,293,678	5,873,399	6,261,534	6,615,100	7,049,665	6,935,687	6,933,359	6,932,456
White	3,987,857	4,041,826	4,178,387	4,000,663	4,497,458	4,757,618	5,066,228	5,192,500	5,033,796	4,947,344	4,887,860
Asian	97,804	107,848	131,093	139,176	182,413	209,380	240,847	311,899	324,604	347,394	358,744
Black	551,243	560,984	555,764	507,619	585,465	607,156	685,382	786,609	792,427	815,881	828,672
Hispanic	256,904	278,577	312,340	297,794	378,513	411,948	469,138	579,329	597,193	630,102	662,310
Native American	38,410	38,932	40,534	36,622	45,764	48,607	55,443	64,307	65,494	68,936	70,505
Foreign citizen	53,934	66,170	69,999	67,650	72,557	80,495	98,062	115,021	122,173	123,702	124,365

SOURCES: National Center for Education Statistics (NCES), *Digest of Education Statistics* (Washington, DC: U.S. Government Printing Office, 1994); NCES, *Trends in Racial/Ethnic Enrollment in Higher Education: Fall 1982 Through Fall 1995* (Washington, DC: U.S. Government Printing Office, 1997); and NCES, unpublished tabulations.

Science & Engineering Indicators – 1998

Appendix table 2-12.

Undergraduate enrollment in engineering and engineering technology programs: 1979-96

Enrollment	1979	1981	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Engineering programs																
Total students	366,299	420,402	441,205	429,499	420,864	407,657	392,198	385,412	378,277	380,287	379,977	382,525	375,944	367,298	363,315	356,177
Total full time	340,488	387,577	406,144	394,635	384,191	369,520	356,998	346,169	338,529	338,842	339,397	344,126	337,817	328,463	325,489	317,772
Freshman	103,724	115,280	109,638	105,249	103,225	99,238	95,453	98,009	95,420	94,346	93,002	93,427	88,875	85,047	86,299	85,375
Sophomore	78,594	87,519	89,515	83,946	79,627	76,195	73,317	71,030	71,267	72,204	71,257	71,644	69,974	68,177	67,981	66,475
Junior	74,928	86,633	91,233	89,509	84,875	80,386	77,085	73,761	70,483	72,666	73,516	74,871	73,449	71,753	68,894	67,190
Senior	77,823	92,414	109,036	109,695	110,305	107,773	104,003	97,614	94,465	92,989	94,683	98,235	98,214	96,523	95,226	92,213
Fifth year	5,419	5,731	6,722	6,236	6,159	5,928	7,140	5,755	6,894	6,637	6,939	5,949	7,305	6,963	7,089	6,519
Total part time	25,811	32,825	35,061	34,864	36,673	38,137	35,200	39,243	39,748	41,445	40,580	38,399	38,127	38,835	37,826	38,405
Total schools	286	286	292	289	297	311	316	320	323	328	336	337	336	337	337	335
ABET-accredited schools[a]	239	250	258	258	264	270	277	281	284	289	303	309	310	315	316	317
Engineering technology programs																
Total students	NA	191,152	163,226	157,897	123,571	137,390	128,501	131,704	127,687	123,217	127,135	124,736	106,976	107,275	105,809	105,345
Total full time	NA	134,444	112,745	111,446	83,038	90,536	80,600	79,624	76,179	72,390	75,340	73,245	65,581	66,457	63,929	62,330
First year	NA	65,893	53,032	46,806	34,389	39,177	32,685	33,477	32,225	30,178	31,302	30,543	24,824	24,574	25,665	26,583
Second year	NA	40,774	33,799	31,716	23,293	25,612	22,906	21,852	21,627	20,586	20,815	21,081	19,962	20,997	18,863	17,267
Other years assoc.	NA	872	925	1,165	466	657	1,404	1,760	1,810	1,603	2,221	2,336	2,564	3,121	2,007	2,780
BA of engineering tech																
Third and later years	NA	26,905	24,989	31,759	24,890	25,090	23,605	22,535	20,517	20,023	21,002	19,285	18,231	17,765	17,394	15,700
Total part time	NA	56,708	50,481	46,451	40,533	46,854	47,901	52,080	51,508	50,827	51,795	51,491	41,395	40,818	41,880	43,015
Total schools	NA	NA	NA	NA	200	257	291	310	286	303	302	298	263	294	289	285

NA = not available

[a] Schools with at least one curriculum accredited by the Accreditation Board of Engineering and Technology (ABET).

SOURCE: American Association of Engineering Societies, Engineering Workforce Commission, *Engineering and Technology Enrollments, Fall 1979-1996* (Washington, DC: 1996), unpublished tabulations.

Science & Engineering Indicators – 1998

Appendix table 2-13.

Engineering enrollment, by attendance pattern: 1979-96

	Undergraduate			Graduate		
	Total	Full time	Part time	Total	Full time	Part time
			Number			
1979	366,299	340,488	25,811	67,152	41,384	25,768
1980	397,344	365,117	32,227	72,585	44,335	28,250
1981	420,402	387,577	32,825	77,600	47,782	29,818
1982	435,330	403,390	31,940	81,999	50,410	31,589
1983	441,205	406,144	35,061	91,040	57,366	33,674
1984	429,499	394,635	34,864	93,165	57,277	35,888
1985	420,864	384,191	36,673	95,505	60,641	34,864
1986	407,657	369,520	38,137	107,196	67,333	39,863
1987	392,198	356,998	35,200	110,778	69,343	41,435
1988	385,412	346,169	39,243	112,007	69,226	42,781
1989	378,277	338,529	39,748	114,048	68,967	45,081
1990	380,287	338,842	41,445	117,834	72,456	45,378
1991	379,977	339,397	40,580	123,497	74,568	48,929
1992	382,525	344,126	38,399	128,854	78,651	50,203
1993	375,944	337,817	38,127	128,081	78,885	49,196
1994	367,298	328,463	38,835	122,242	74,596	47,646
1995	363,315	325,489	37,826	118,506	72,215	46,291
1996	356,177	317,772	38,405	113,063	70,129	42,934
			Percent			
1979	100.0	93.0	7.0	100.0	61.6	38.4
1980	100.0	91.9	8.1	100.0	61.1	38.9
1981	100.0	92.2	7.8	100.0	61.6	38.4
1982	100.0	92.7	7.3	100.0	61.5	38.5
1983	100.0	92.1	7.9	100.0	63.0	37.0
1984	100.0	91.9	8.1	100.0	61.5	38.5
1985	100.0	91.3	8.7	100.0	63.5	36.5
1986	100.0	90.6	9.4	100.0	62.8	37.2
1987	100.0	91.0	9.0	100.0	62.6	37.4
1988	100.0	89.8	10.2	100.0	61.8	38.2
1989	100.0	89.5	10.5	100.0	60.5	39.5
1990	100.0	89.1	10.9	100.0	61.5	38.5
1991	100.0	89.3	10.7	100.0	60.4	39.6
1992	100.0	90.0	10.0	100.0	61.0	39.0
1993	100.0	89.9	10.1	100.0	61.6	38.4
1994	100.0	89.4	10.6	100.0	61.0	39.0
1995	100.0	89.6	10.4	100.0	60.9	39.1
1996	100.0	89.2	10.8	100.0	62.0	38.0

SOURCE: American Association of Engineering Societies, Engineering Workforce Commission, *Engineering and Technology Enrollments, Fall 1979-1996* (Washington, DC: 1996), unpublished tabulations.

Science & Engineering Indicators – 1998

Appendix table 2-14.

Undergraduate enrollment in engineering, by sex, race/ethnicity, and citizenship: 1979-96

		Sex		Race/ethnicity and citizenship						
						Underrepresented minorities				
	Total	Male	Female	White	Asian	Total	Black	Hispanic	Native American	Foreign citizen
				Number						
1979	366,299	321,868	44,431	302,566	12,243	28,729	15,842	12,068	819	22,761
1981	420,402	361,133	59,269	343,649	15,815	34,353	18,911	14,359	1,083	26,585
1983	441,205	372,374	68,831	354,329	23,007	37,432	19,698	16,462	1,272	26,437
1984	429,499	362,800	66,699	340,374	25,449	37,557	19,204	17,075	1,278	26,119
1985	420,864	354,612	66,252	323,899	28,767	39,657	19,819	18,598	1,240	28,541
1986	407,657	344,999	62,658	315,861	30,201	37,240	18,459	17,586	1,195	24,355
1987	392,198	331,917	60,281	296,749	32,795	38,640	19,142	18,253	1,245	24,014
1988	385,412	325,024	60,388	288,415	34,051	40,389	20,405	18,700	1,284	22,557
1989	378,277	318,067	60,210	281,948	33,360	41,338	21,013	19,007	1,318	21,631
1990	380,287	319,506	60,781	288,732	30,898	41,169	20,833	18,873	1,463	19,488
1991	379,977	316,719	63,258	271,906	37,803	48,692	24,563	22,441	1,688	21,576
1992	382,525	316,460	66,065	270,942	38,480	51,517	25,722	23,863	1,932	21,586
1993	375,944	309,412	66,532	263,073	37,835	52,437	25,920	24,586	1,931	22,599
1994	367,298	300,643	66,655	256,287	37,009	52,188	24,994	25,216	2,028	21,764
1995	363,315	296,029	67,286	249,896	38,329	53,670	25,569	25,998	2,103	21,420
1996	356,177	288,559	67,618	243,270	37,873	53,801	24,922	26,483	2,396	21,233
				Percent						
1979	100.0	87.9	12.1	82.6	3.3	7.8	4.3	3.3	0.2	6.2
1981	100.0	85.9	14.1	81.7	3.8	8.2	4.5	3.4	0.3	6.3
1983	100.0	84.4	15.6	80.3	5.2	8.5	4.5	3.7	0.3	6.0
1984	100.0	84.5	15.5	79.2	5.9	8.7	4.5	4.0	0.3	6.1
1985	100.0	84.3	15.7	77.0	6.8	9.4	4.7	4.4	0.3	6.8
1986	100.0	84.6	15.4	77.5	7.4	9.1	4.5	4.3	0.3	6.0
1987	100.0	84.6	15.4	75.7	8.4	9.9	4.9	4.7	0.3	6.1
1988	100.0	84.3	15.7	74.8	8.8	10.5	5.3	4.9	0.3	5.9
1989	100.0	84.1	15.9	74.5	8.8	10.9	5.6	5.0	0.3	5.7
1990	100.0	84.1	16.0	75.9	8.1	10.8	5.5	5.0	0.4	5.1
1991	100.0	83.4	16.6	71.6	9.9	12.8	6.5	5.9	0.4	5.7
1992	100.0	82.7	17.3	70.8	10.1	13.5	6.7	6.2	0.5	5.6
1993	100.0	82.3	17.7	70.0	10.1	13.9	6.9	6.5	0.5	6.0
1994	100.0	81.9	18.1	69.8	10.1	14.2	6.8	6.9	0.6	5.9
1995	100.0	81.5	18.5	68.8	10.5	14.8	7.0	7.2	0.6	5.9
1996	100.0	79.4	18.6	67.0	10.4	14.8	6.9	7.3	0.7	5.8

SOURCE: American Association of Engineering Societies, Engineering Workforce Commission, *Engineering and Technology Enrollments, Fall 1979-1996* (Washington, DC: 1996), unpublished tabulations.

See figure 2-10.

Science & Engineering Indicators – 1998

Appendix table 2-15.

Proportion of freshmen intending to major in science and engineering, by field, sex, and race/ethnicity: 1976-96

(Percentages)

Field and sex	1976	1978	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
All freshmen	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
White students																			
Total intending S&E majors	31.4	30.2	30.3	29.9	31.3	31.4	30.9	29.8	27.8	27.0	26.5	29.0	28.4	30.2	30.2	31.1	31.0	30.3	32.2
Natural sciences[a]	13.2	9.6	8.5	8.0	7.4	7.7	8.1	7.7	6.9	6.5	6.6	6.9	7.5	8.5	9.2	10.0	11.9	12.0	11.6
Math & comp. sciences	2.3	2.6	3.1	4.7	5.9	5.7	3.8	3.1	2.5	2.2	2.1	2.3	2.2	2.1	2.1	2.4	2.3	2.5	2.7
Social sciences[b]	7.3	7.7	7.3	6.3	6.4	6.5	8.0	8.3	8.2	9.7	9.6	10.5	9.9	9.0	9.5	9.4	8.9	8.5	9.0
Engineering	8.6	10.3	11.4	10.9	11.6	11.5	11.0	10.7	10.2	8.6	8.2	9.3	8.8	10.6	9.4	9.3	7.9	7.3	8.9
Males intending S&E majors	41.7	39.3	40.6	40.5	41.5	42.5	41.0	38.7	35.9	34.0	33.7	36.6	35.3	37.5	37.4	38.2	37.5	36.8	38.8
Natural sciences[a]	16.6	11.8	10.4	10.2	9.9	10.0	9.6	9.4	8.2	7.9	8.5	8.2	9.0	8.7	10.4	11.0	12.7	12.7	11.5
Math & comp. sciences	2.7	3.0	3.7	5.6	6.6	6.6	4.9	4.0	3.3	3.2	3.0	3.4	3.0	3.0	2.9	3.5	3.5	4.2	4.3
Social sciences[b]	7.5	6.7	6.5	5.5	5.1	5.9	6.6	6.7	6.2	7.2	7.4	8.2	7.8	7.0	7.6	7.6	7.5	6.6	6.8
Engineering	14.9	17.8	20.0	19.2	19.9	20.0	19.9	18.6	18.2	15.7	14.8	16.8	15.5	18.8	16.5	16.1	13.8	13.3	16.2
Females intending S&E majors	20.9	21.1	20.1	21.0	21.6	21.7	21.3	21.6	20.1	21.0	20.6	22.9	22.5	24.1	24.1	24.9	25.6	25.3	26.5
Natural sciences[a]	9.4	7.7	6.2	6.1	5.3	5.7	6.2	6.2	5.7	5.2	5.1	6.0	6.0	8.4	8.2	9.1	11.0	11.6	11.5
Math & comp. sciences	1.9	2.2	2.6	3.9	5.3	4.9	2.7	2.1	1.8	1.3	1.4	1.3	1.6	1.3	1.3	1.1	1.2	1.1	1.2
Social sciences[b]	7.7	8.7	8.2	7.4	7.5	7.4	9.6	10.2	10.0	12.3	11.7	12.8	11.9	11.3	11.5	11.1	10.4	10.4	10.9
Engineering	1.9	2.5	3.1	3.6	3.5	3.7	2.8	3.1	2.6	2.2	2.4	2.8	3.0	3.1	3.1	3.6	3.0	2.2	2.9
Asian students																			
Total intending S&E majors	49.8	45.9	48.4	47.6	49.8	50.1	48.7	51.1	46.2	47.2	44.7	43.1	42.9	44.2	43.7	42.9	44.9	40.6	42.9
Natural sciences[a]	20.3	16.1	11.9	12.7	13.3	15.0	15.2	15.9	14.5	15.1	14.6	11.9	12.8	14.7	16.1	16.2	16.4	15.3	16.2
Math & comp. sciences	3.8	4.1	5.0	6.1	7.3	7.5	5.4	3.2	4.2	3.9	3.3	2.7	3.5	3.6	2.5	2.9	4.2	4.6	4.9
Social sciences[b]	7.9	6.5	5.9	5.7	6.2	6.1	6.5	7.7	6.9	8.5	9.8	9.3	9.7	8.5	8.5	9.1	8.0	7.3	7.7
Engineering	17.8	19.2	25.6	23.1	23.0	21.5	21.6	24.3	20.6	19.7	17.0	19.2	16.9	17.4	16.6	14.7	16.3	13.4	14.1
Males intending S&E majors	60.3	55.2	59.3	58.3	59.6	59.8	59.9	60.0	56.2	55.5	52.8	51.8	52.3	54.1	51.3	50.8	52.6	48.5	50.1
Natural sciences[a]	20.9	15.8	13.5	13.2	14.7	16.9	16.3	15.7	14.9	14.5	15.5	13.1	14.4	15.5	16.3	16.3	16.3	15.1	15.0
Math & comp. sciences	3.8	4.0	3.8	5.4	5.7	6.6	5.5	3.1	4.4	4.6	3.9	3.1	4.7	4.8	3.6	4.1	5.8	6.5	7.3
Social sciences[b]	5.9	5.0	4.0	3.4	4.3	3.9	5.1	6.5	4.2	5.4	6.9	5.6	6.6	5.8	5.7	6.5	5.0	4.7	4.8
Engineering	29.7	30.4	38.0	36.3	34.9	32.4	33.0	34.7	32.7	31.0	26.5	30.0	26.6	28.0	25.7	23.9	25.5	22.2	23.0
Females intending S&E majors	38.3	36.7	34.7	36.3	40.0	39.5	37.4	40.4	36.2	37.8	36.2	34.7	33.8	34.6	36.2	34.9	36.4	33.7	35.3
Natural sciences[a]	19.6	16.5	10.1	11.9	11.7	12.9	14.0	16.2	14.3	15.5	13.7	11.4	11.1	14.3	15.7	15.8	16.7	15.8	17.0
Math & comp. sciences	3.7	4.3	6.5	7.0	9.1	8.4	5.4	3.3	4.1	3.2	2.8	2.4	2.4	2.4	1.6	1.9	2.4	2.7	2.5
Social sciences[b]	10.0	8.0	7.6	7.9	8.7	8.1	7.6	8.6	9.7	11.5	13.1	13.5	12.8	11.2	11.4	11.4	10.7	9.7	10.4
Engineering	5.0	7.9	10.5	9.5	10.5	10.1	10.4	12.3	8.1	7.6	6.6	7.4	7.5	6.7	7.5	5.8	6.6	5.5	5.4
Black students																			
Total intending S&E majors	31.7	30.7	30.4	30.7	33.3	31.5	28.9	30.4	27.9	30.7	31.1	31.2	31.4	35.3	37.1	37.7	35.6	35.5	36.2
Natural sciences[a]	8.9	5.7	4.7	5.0	5.3	5.3	5.8	5.8	4.8	5.1	4.7	5.7	5.3	6.4	7.8	8.9	8.8	10.4	10.0
Math & comp. sciences	1.5	2.6	4.7	6.8	8.3	9.0	6.9	7.0	4.5	4.4	4.0	4.4	4.5	5.0	4.7	4.8	4.5	5.3	5.5
Social sciences[b]	14.7	14.1	10.7	9.0	8.3	8.4	8.7	8.1	10.2	10.7	14.3	11.9	12.7	11.6	11.9	11.1	12.7	11.2	11.6
Engineering	6.6	8.3	10.3	9.9	11.4	8.8	7.5	9.5	8.4	10.5	8.1	9.2	8.9	12.3	12.7	12.9	9.6	8.6	9.1

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Appendix table 2-15.

Proportion of freshmen intending to major in science and engineering, by field, sex, and race/ethnicity: 1976-96

(Percentages)

Field and sex	1976	1978	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Males intending S&E majors ...	34.2	33.1	34.8	35.9	38.5	35.7	33.5	34.8	31.8	35.0	34.1	34.2	32.8	39.7	41.8	42.8	38.1	37.7	37.2
Natural sciences[a]	10.4	6.0	5.0	5.7	5.8	6.2	6.3	5.8	5.0	5.3	5.7	5.2	5.7	6.0	7.7	8.5	8.1	9.4	7.7
Math & comp. sciences	1.6	3.2	4.8	7.0	8.0	8.9	7.4	7.8	4.9	5.3	4.2	5.3	5.0	5.0	5.0	5.7	5.0	6.6	6.9
Social sciences[b]	9.6	8.4	6.5	6.0	5.4	5.3	7.0	5.3	7.1	6.9	9.7	7.7	7.4	7.4	8.0	7.4	8.0	6.2	6.2
Engineering	12.6	15.5	18.5	17.2	19.3	15.3	12.8	15.9	14.8	17.5	14.5	16.0	14.7	21.3	21.1	21.2	17.0	15.5	16.4
Females intending S&E majors	24.0	23.3	23.4	24.3	27.2	25.5	23.4	25.0	23.0	25.8	26.7	27.5	28.0	30.7	32.1	32.8	30.4	31.5	32.1
Natural sciences[a]	7.5	5.8	4.4	4.8	4.9	4.3	5.6	5.9	4.4	4.7	4.1	5.8	5.6	6.8	8.0	9.5	8.9	10.7	10.5
Math & comp. sciences	1.4	2.3	4.6	6.6	8.5	9.1	6.6	6.5	4.3	3.8	3.8	4.0	4.1	5.0	4.5	4.2	4.2	4.5	4.7
Social sciences[b]	12.8	12.0	9.7	8.3	7.9	7.9	7.5	7.7	10.0	11.3	14.8	12.3	13.3	12.3	12.7	11.5	12.4	11.8	12.4
Engineering	2.3	3.2	4.7	4.6	5.9	4.2	3.7	4.9	4.3	6.0	4.0	5.4	5.0	6.6	6.9	7.6	4.9	4.5	4.5
Hispanic students																			
Total intending S&E majors	32.0	27.2	35.1	34.3	32.9	34.1	32.2	36.5	34.7	34.1	30.5	32.6	33.4	30.0	33.4	34.2	37.8	37.2	35.0
Natural sciences[a]	11.6	6.8	8.9	9.3	6.8	8.4	8.1	8.8	8.6	8.2	6.8	7.3	7.4	7.4	8.8	9.4	10.2	11.0	9.9
Math & comp. sciences	1.7	2.0	3.1	3.5	5.2	4.7	6.1	3.4	2.5	2.1	2.1	2.2	2.3	2.6	2.4	2.0	2.6	2.6	2.9
Social sciences[b]	10.6	9.4	10.4	7.4	9.0	8.3	7.8	11.5	11.4	12.5	12.6	12.8	12.8	9.7	12.0	12.5	13.6	12.5	12.1
Engineering	8.1	9.0	12.7	14.1	11.9	12.7	10.2	12.8	12.2	11.3	9.0	10.3	10.9	10.3	10.2	10.3	11.4	11.1	10.1
Males intending S&E majors ...	39.5	34.0	41.3	41.7	39.8	40.3	41.7	44.3	41.7	40.7	35.4	38.7	39.0	34.8	37.6	38.7	42.1	41.4	41.2
Natural sciences[a]	14.0	7.8	9.4	9.0	7.9	8.8	9.0	9.9	8.7	8.7	7.5	7.8	8.9	7.4	9.2	9.8	10.4	9.1	9.9
Math & comp. sciences	2.6	3.3	2.7	4.0	5.1	5.5	7.7	4.6	3.0	2.5	2.7	2.8	2.7	3.6	3.2	2.8	4.0	3.9	4.3
Social sciences[b]	8.6	6.9	8.1	5.1	7.3	6.4	7.7	8.4	8.0	10.1	9.3	9.9	7.9	6.8	8.1	9.4	9.1	8.2	8.8
Engineering	14.3	16.0	21.1	23.6	19.5	19.6	17.3	21.4	22.0	19.4	15.9	18.2	19.5	17.0	17.1	16.7	18.6	20.2	18.2
Females intending S&E majors	24.0	21.0	30.0	26.9	26.6	28.7	24.5	30.0	29.0	29.0	26.7	28.2	28.9	25.7	29.6	29.6	34.7	32.0	30.1
Natural sciences[a]	8.9	6.1	8.7	9.4	5.6	8.0	7.4	7.8	8.6	7.9	6.1	7.0	6.2	7.9	8.5	8.7	10.2	11.1	9.6
Math & comp. sciences	0.9	0.9	3.5	2.9	5.4	4.0	4.8	2.2	2.1	1.8	1.7	1.7	2.1	1.7	1.6	1.2	1.6	1.4	1.9
Social sciences[b]	12.8	11.9	12.4	9.2	10.5	10.3	7.9	14.1	14.2	14.7	15.3	15.3	16.2	12.4	15.3	15.3	17.2	16.0	14.6
Engineering	1.4	2.1	5.4	5.4	5.1	6.4	4.4	5.9	4.1	4.6	3.6	4.2	4.4	3.7	4.2	4.4	5.7	3.5	4.0
Native American students																			
Total intending S&E majors	30.5	32.0	34.0	26.8	27.7	26.1	27.1	26.4	29.6	30.7	30.8	32.7	30.9	30.3	30.9	30.8	30.0	29.8	32.2
Natural sciences[a]	13.7	9.3	7.6	6.6	6.7	6.7	9.2	6.9	7.8	8.4	7.4	6.5	10.7	8.4	9.1	9.5	9.4	11.3	11.8
Math & comp. sciences	2.5	2.2	3.9	3.0	4.6	4.7	3.6	3.3	2.3	2.6	2.3	1.8	1.6	2.4	2.0	2.4	2.4	2.5	3.3
Social sciences[b]	7.8	10.2	9.2	7.0	5.9	5.9	6.6	9.5	9.5	9.7	12.6	13.9	10.6	9.6	10.6	10.6	10.3	9.6	10.2
Engineering	6.5	10.3	13.3	10.2	10.5	8.8	7.7	6.7	10.0	10.0	8.5	10.5	8.0	9.9	9.2	8.3	6.8	6.4	6.9
Males intending S&E majors ...	39.4	38.1	41.5	39.2	34.2	35.2	33.2	32.6	39.7	39.9	37.3	39.1	35.9	36.6	37.6	36.5	34.1	36.3	38.5
Natural sciences[a]	17.2	11.8	9.9	8.8	6.9	9.7	9.9	10.3	9.8	11.0	9.5	8.5	12.3	8.4	9.6	11.7	10.0	11.8	11.6
Math & comp. sciences	3.4	1.9	4.8	4.7	6.1	5.1	3.5	4.6	3.0	3.4	3.4	2.0	2.2	3.3	3.0	2.8	3.5	4.3	5.7
Social sciences[b]	7.0	7.5	7.5	6.2	2.7	5.6	5.8	6.3	9.5	7.3	8.5	11.4	7.4	6.7	9.2	8.3	8.1	7.3	7.8
Engineering	11.8	16.9	19.3	19.5	18.5	14.8	14.0	11.4	17.4	18.2	15.9	17.2	14.0	18.2	15.8	13.7	12.5	12.9	13.4
Females intending S&E majors	21.8	25.9	26.7	15.6	22.4	18.8	22.1	20.6	21.4	23.8	25.6	28.1	26.8	25.5	25.6	26.5	26.5	25.2	27.5
Natural sciences[a]	10.6	6.9	5.3	4.5	6.7	4.6	9.0	3.9	5.9	6.7	5.7	5.2	9.1	8.5	8.5	7.8	10.1	11.0	11.7
Math & comp. sciences	1.6	2.6	3.2	1.5	3.1	4.4	3.7	2.1	1.8	1.9	1.4	1.5	1.3	1.7	1.2	2.1	1.5	1.2	1.6
Social sciences[b]	8.5	12.8	11.3	7.7	8.9	6.1	7.4	12.1	9.5	11.4	16.1	15.6	13.0	11.9	11.8	12.2	12.1	11.2	11.7
Engineering	1.1	3.6	6.9	1.9	3.7	3.7	2.0	2.5	4.2	3.8	2.4	5.8	3.4	3.4	4.1	4.4	2.8	1.8	2.5

[a] Natural sciences here include physical, earth, atmospheric, oceanographic, biological, and agricultural sciences.

[b] Social sciences include psychology, sociology, and other social sciences.

SOURCE: University of California at Los Angeles, Higher Education Research Institute, *Survey of the American Freshman: National Norms* (Los Angeles: 1995), unpublished tabulations.

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Appendix table 2-16.

Race/ethnicity of freshmen intending to major in science and engineering, by selected fields: 1976-96

(Percentages)

Field/subfield	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
White freshmen intending S&E majors																					
All S&E fields	87.6	87.1	87.9	86.2	85.9	87.4	85.2	85.7	85.9	84.1	84.1	83.1	80.2	81.9	78.9	76.9	78.9	79.1	76.7	76.5	76.7
Physical sciences	89.5	90.5	91.4	89.9	90.0	89.9	87.9	89.5	89.0	85.1	87.4	87.3	87.7	86.0	86.5	82.5	83.8	82.6	80.3	82.7	81.2
Biological sciences	88.8	89.4	89.0	88.1	88.3	87.8	85.8	85.2	84.2	83.8	82.7	81.8	79.9	80.8	77.8	76.2	78.4	78.6	77.8	76.6	76.4
Social sciences	84.0	83.1	83.5	83.3	83.4	87.0	84.7	84.8	85.4	87.2	84.4	85.0	80.5	83.6	78.2	77.8	80.0	80.1	77.7	77.6	77.7
Engineering	88.8	88.0	89.2	86.7	86.1	87.5	85.8	87.3	87.8	83.4	84.1	81.6	80.2	81.1	79.3	76.1	77.2	77.3	73.8	74.3	76.0
Asian freshmen intending S&E majors																					
All S&E fields	1.8	1.8	1.8	2.2	2.2	2.0	2.5	2.8	2.7	4.4	4.6	4.8	5.2	4.8	5.3	6.0	5.8	5.7	7.9	7.0	6.8
Physical sciences	2.3	2.7	2.3	2.8	2.3	2.8	3.6	3.5	4.0	6.1	5.4	5.0	5.5	4.4	5.4	5.8	5.9	5.5	8.0	6.8	6.6
Biological sciences	2.1	2.1	2.3	2.2	2.5	2.5	3.2	4.2	3.9	6.6	7.1	7.7	8.6	7.0	7.7	9.2	8.4	8.1	9.8	8.6	8.5
Social sciences	0.9	1.0	1.0	0.9	1.1	1.1	1.6	1.4	1.6	2.5	2.5	2.8	3.4	3.1	3.7	4.2	3.8	4.5	5.0	4.8	4.6
Engineering	2.4	2.4	2.2	3.1	2.9	2.7	3.0	3.4	3.5	5.7	5.8	6.0	6.4	6.4	6.4	6.7	6.9	6.3	10.5	8.9	8.0
Black freshmen intending S&E majors																					
All S&E fields	8.5	8.6	8.2	9.1	9.7	8.6	10.4	9.7	9.5	9.4	8.6	9.6	11.6	10.3	12.1	13.2	11.2	11.4	11.1	11.5	11.7
Physical sciences	6.3	5.0	4.7	5.8	6.0	5.6	6.9	6.0	5.6	7.7	5.3	5.7	5.3	7.2	5.3	8.6	7.2	9.0	8.7	8.1	9.1
Biological sciences	6.9	6.2	6.3	6.7	7.0	7.1	8.9	7.9	9.5	6.8	6.8	7.6	8.1	9.0	10.2	10.0	8.9	9.2	8.4	10.6	10.3
Social sciences	12.5	12.8	12.7	12.7	12.4	10.1	10.7	11.9	11.4	8.9	10.3	9.7	13.0	10.2	14.1	13.7	11.5	10.9	12.1	11.5	12.8
Engineering	6.8	7.3	6.7	7.7	8.7	7.6	9.4	7.6	7.0	8.5	7.4	9.8	10.1	9.4	10.6	13.4	12.2	12.7	11.0	10.9	10.7
Hispanic freshmen intending S&E majors																					
All S&E fields	1.3	1.9	1.4	2.0	1.6	1.3	1.8	1.3	1.2	1.6	2.1	1.9	2.3	2.3	2.5	2.7	4.1	5.9	7.1	7.6	8.0
Physical sciences	1.3	0.6	1.1	1.5	1.2	1.3	1.0	0.7	1.2	1.0	1.2	1.4	1.7	1.7	1.8	2.1	2.6	2.9	4.0	2.8	3.4
Biological sciences	1.9	1.9	1.9	2.2	1.9	2.6	2.0	1.8	1.9	1.8	2.2	2.2	2.7	2.2	2.5	2.8	4.2	5.9	4.1	4.5	4.6
Social sciences	1.8	2.6	2.0	2.6	2.1	1.4	2.0	1.5	1.2	1.5	2.1	1.9	2.5	2.4	2.7	2.9	4.9	7.5	5.6	6.1	5.8
Engineering	1.1	1.5	1.3	1.6	1.3	1.3	1.7	1.3	1.1	1.5	2.1	1.9	2.2	2.2	2.5	2.5	3.9	5.3	5.3	5.9	5.1
Native American freshmen intending S&E majors																					
All S&E fields	0.9	0.7	0.7	0.8	0.8	0.9	0.9	1.0	0.9	0.9	0.9	1.0	0.9	1.0	1.3	1.7	1.8	1.8	2.1	2.1	2.3
Physical sciences	1.2	0.5	0.6	1.0	0.6	0.8	0.9	1.3	0.6	0.8	1.1	1.1	0.8	0.9	2.1	1.5	1.5	1.3	2.1	2.2	2.9
Biological sciences	1.0	0.8	0.7	0.7	0.8	0.8	1.0	1.1	1.5	1.2	1.0	1.1	1.0	0.9	1.6	1.8	1.8	1.9	2.0	2.3	2.3
Social sciences	1.0	0.8	0.8	0.8	0.9	1.1	0.9	1.4	0.6	0.9	1.0	1.0	0.9	1.2	1.3	1.9	1.8	2.3	2.2	2.5	2.2
Engineering	0.7	0.5	0.6	0.7	0.7	0.9	0.9	0.9	0.7	0.6	0.9	1.0	0.8	1.0	1.1	1.5	1.6	1.5	1.7	1.8	1.8

NOTE: Details may not add to totals because students may check more than one race/ethnicity, e.g., white and Hispanic.

SOURCE: University of California at Los Angeles, Higher Education Research Institute, *Survey of the American Freshman: National Norms* (Los Angeles: 1997), unpublished tabulations.

See figure 2-9.

Science & Engineering Indicators – 1998

Appendix table 2-17.

Freshmen reporting need for remedial work in science or mathematics, by intended major, sex, and race/ethnicity: 1995

(Percentages)

Sex, race/ethnicity	All S&E majors needing remedial work in:		Physical science majors needing remedial work in:		Biological science majors needing remedial work in:		Social science majors needing remedial work in:		Engineering majors needing remedial work in:		Non-S&E majors needing remedial work in:	
	Science	Math	Science	Math	Science	Math	Science	Math	Science	Math	Science	Math
All students	9.5	21.2	6.2	13.0	9.7	22.0	10.5	27.5	9.0	14.3	10.9	25.0
Male	7.6	16.4	5.3	11.3	13.2	25.2	7.0	20.2	8.3	13.9	8.4	20.8
Female	11.4	26.6	7.6	15.5	10.8	24.4	12.8	32.2	12.2	15.5	12.7	28.0
White	6.8	17.8	4.4	11.1	6.8	19.1	8.5	24.2	5.7	10.3	9.0	22.0
Asian	15.9	20.6	11.1	10.2	15.4	20.3	20.0	26.9	14.8	18.1	22.8	25.7
Black	20.2	41.8	23.0	39.9	23.8	41.8	16.1	47.5	19.0	31.1	18.8	47.1
Hispanic	21.6	38.3	10.4	20.7	19.9	36.3	20.0	41.2	25.9	34.1	18.1	37.0
Native American	12.0	29.8	5.7	9.8	13.6	33.7	10.9	36.3	14.3	17.8	12.5	39.1

SOURCE: University of California at Los Angeles, Higher Education Research Institute, *Survey of the American Freshman: National Norms* (Los Angeles: 1997), unpublished tabulations.

See figure 2-8.

Science & Engineering Indicators – 1998

Appendix table 2-18.

Earned associate degrees, by field and sex: 1975-95

Field	1975	1977	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
All students																			
All degrees	362,969	409,942	407,471	405,710	420,910	440,000	461,888	457,851	459,087	451,258	440,816	441,093	440,375	459,048	486,297	508,704	519,098	546,574	544,094
S&E	NA	NA	NA	NA	NA	NA	23,796	28,095	26,486	25,267	23,130	21,520	19,733	19,810	19,352	22,722	23,420	25,581	24,228
Natural sciences[a]	NA	NA	NA	NA	NA	NA	5,013	4,990	4,321	3,924	3,694	3,818	3,712	3,996	4,112	4,585	4,787	5,484	5,456
Math & comp. sci.	NA	NA	NA	NA	NA	NA	10,707	13,696	13,680	11,567	9,953	9,575	8,846	8,600	8,640	10,376	10,275	10,634	10,410
Social sciences[b]	NA	NA	NA	NA	NA	NA	4,803	4,852	4,562	4,487	4,894	4,231	4,440	4,809	4,087	5,046	5,832	6,619	6,077
Engineering	NA	NA	NA	NA	NA	NA	3,273	4,557	3,923	5,289	4,589	3,896	2,735	2,405	2,513	2,715	2,526	2,844	2,285
Engineering tech.	30,906	38,588	41,716	43,696	52,478	58,574	51,317	50,671	53,667	49,880	49,815	49,646	48,342	46,938	45,106	40,592	40,946	42,414	39,190
Males																			
All degrees	191,855	212,120	193,696	185,329	190,152	198,698	208,830	204,517	204,325	197,955	192,227	191,912	187,125	192,433	200,043	208,856	213,263	222,247	219,704
S&E	NA	NA	NA	NA	NA	NA	13,145	15,689	14,695	14,403	13,152	12,266	10,607	10,568	10,360	12,063	12,103	13,023	12,461
Natural sciences[a]	NA	NA	NA	NA	NA	NA	2,959	2,927	2,460	2,173	2,113	2,151	1,965	2,195	2,278	2,605	2,686	2,948	2,978
Math & comp. sci.	NA	NA	NA	NA	NA	NA	5,395	7,007	7,128	6,015	5,297	5,028	4,563	4,431	4,438	5,187	5,123	5,384	5,434
Social sciences[b]	NA	NA	NA	NA	NA	NA	1,876	1,713	1,606	1,588	1,650	1,617	1,671	1,825	1,411	1,911	2,098	2,217	2,071
Engineering	NA	NA	NA	NA	NA	NA	2,915	4,042	3,501	4,627	4,092	3,470	2,408	2,117	2,233	2,360	2,196	2,474	1,978
Engineering tech.	29,108	34,957	36,749	37,847	45,329	50,823	45,521	45,068	47,946	44,340	44,158	44,053	42,766	41,435	39,777	35,666	36,129	36,899	34,196
Females																			
All degrees	171,114	197,822	213,775	220,381	230,758	241,302	253,058	253,334	254,762	253,303	248,589	249,181	253,250	266,615	286,254	299,848	305,835	324,327	324,390
S&E	NA	NA	NA	NA	NA	NA	10,651	12,406	11,791	10,864	9,978	9,254	9,126	9,242	8,992	10,659	11,317	12,558	11,767
Natural sciences[a]	NA	NA	NA	NA	NA	NA	2,054	2,063	1,861	1,751	1,581	1,667	1,747	1,801	1,834	1,980	2,101	2,536	2,478
Math & comp. sci.	NA	NA	NA	NA	NA	NA	5,312	6,689	6,552	5,552	4,656	4,547	4,283	4,169	4,202	5,189	5,152	5,250	4,976
Social sciences[b]	NA	NA	NA	NA	NA	NA	2,927	3,139	2,956	2,899	3,244	2,614	2,769	2,984	2,676	3,135	3,734	4,402	4,006
Engineering	NA	NA	NA	NA	NA	NA	358	515	422	662	497	426	327	288	280	355	330	370	307
Engineering tech.	1,798	3,631	4,967	5,849	7,149	7,751	5,796	5,603	5,721	5,540	5,657	5,593	5,576	5,503	5,329	4,926	4,817	5,515	4,994

NA = not available

NOTE: Data on associate degrees are not available for broad science and engineering fields before 1983.

[a] Natural sciences here include physical, earth, atmospheric, oceanographic, biological, and agricultural sciences.

[b] Social sciences include psychology, sociology, and other social sciences.

SOURCES: National Center for Education Statistics, Earned Degrees and Completion Surveys (Washington, DC: 1995), unpublished tabulations; and National Science Foundation, Science Resources Studies Division, unpublished tabulations.

See figure 2-5.

Science & Engineering Indicators – 1998

Appendix table 2-19.

Earned associate degrees, by field and race/ethnicity: 1977-95

Field	1977	1979	1981	1985	1987	1989	1990	1991	1992	1993	1994	1995
All students												
All degrees	409,942	407,471	420,910	459,087	440,816	440,375	459,048	486,297	508,704	519,098	546,574	544,094
Science and engineering	NA	NA	NA	25,957	22,167	19,479	19,406	19,154	22,361	23,118	25,172	23,644
Natural sciences[a]	NA	NA	NA	4,691	3,950	3,952	4,286	4,430	4,859	5,090	5,793	5,790
Math and computer sciences	NA	NA	NA	13,679	9,953	8,846	8,600	8,640	10,346	10,255	10,532	10,230
Social sciences[b]	NA	NA	NA	3,664	3,676	3,949	4,118	3,574	4,441	5,248	6,019	5,348
Engineering	NA	NA	NA	3,923	4,588	2,732	2,402	2,510	2,715	2,525	2,828	2,276
Engineering technology	38,244	40,891	51,661	51,579	47,434	46,180	44,739	42,595	38,015	38,473	39,889	36,956
Whites												
All degrees	342,382	331,173	339,183	355,422	345,546	330,557	343,629	376,869	388,049	392,637	419,962	408,126
Science and engineering	NA	NA	NA	18,133	16,169	13,898	13,684	13,842	15,487	15,631	17,809	16,310
Natural sciences[a]	NA	NA	NA	3,548	3,078	3,231	3,458	3,574	3,878	3,989	4,493	4,326
Math and computer sciences	NA	NA	NA	10,255	7,360	6,044	5,704	6,054	6,631	6,515	7,133	6,809
Social sciences[b]	NA	NA	NA	2,070	2,496	2,637	2,752	2,347	2,892	3,241	4,050	3,524
Engineering	NA	NA	NA	2,260	3,235	1,986	1,770	1,867	2,086	1,886	2,133	1,651
Engineering technology	33,109	33,662	40,804	40,934	37,383	33,584	31,699	33,792	28,242	28,442	31,457	27,737
Asians												
All degrees	7,174	7,617	8,757	10,165	11,329	11,761	12,687	15,069	15,369	16,280	18,555	20,976
Science and engineering	NA	NA	NA	828	1,051	834	851	842	1,118	1,108	1,283	1,353
Natural sciences[a]	NA	NA	NA	86	112	120	179	220	253	228	304	331
Math and computer sciences	NA	NA	NA	511	464	401	411	388	548	528	566	603
Social sciences[b]	NA	NA	NA	47	106	119	110	88	132	216	229	267
Engineering	NA	NA	NA	184	369	194	151	146	185	136	184	152
Engineering technology	781	1,132	1,641	1,570	1,989	1,663	1,499	1,496	1,311	1,358	1,258	1,387
Blacks												
All degrees	33,176	34,985	35,330	35,861	33,858	32,185	32,882	37,854	38,721	41,260	45,597	45,923
Science and engineering	NA	NA	NA	1,653	1,766	1,460	1,540	1,631	1,809	1,963	2,069	2,033
Natural sciences[a]	NA	NA	NA	160	198	125	153	149	161	178	206	276
Math and computer sciences	NA	NA	NA	938	961	828	876	921	1,093	1,004	1,120	1,060
Social sciences[b]	NA	NA	NA	407	358	387	423	435	420	580	564	549
Engineering	NA	NA	NA	148	249	120	88	126	135	201	179	148
Engineering technology	1,990	2,022	2,903	3,395	3,100	2,829	2,648	3,030	2,445	2,698	3,197	2,932
Hispanics												
All degrees	19,808	20,710	22,088	22,783	22,804	23,475	24,569	29,019	30,253	33,015	35,557	38,499
Science and engineering	NA	NA	NA	1,380	1,635	1,453	1,289	1,463	1,773	2,152	2,329	2,316
Natural sciences[a]	NA	NA	NA	248	281	236	215	232	238	300	404	425
Math and computer sciences	NA	NA	NA	676	620	609	591	677	918	1,086	1,074	1,131
Social sciences[b]	NA	NA	NA	330	365	432	385	401	485	613	703	599
Engineering	NA	NA	NA	126	369	176	98	153	132	153	148	161
Engineering technology	1,644	1,799	2,219	2,084	2,359	2,232	2,298	2,411	2,317	2,398	2,478	2,687

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Appendix table 2-19.

Earned associate degrees, by field and race/ethnicity: 1977-95

Field	1977	1979	1981	1985	1987	1989	1990	1991	1992	1993	1994	1995
Native Americans												
All degrees	2,499	2,336	2,584	2,953	3,049	3,102	3,290	3,772	3,874	4,213	4,879	5,352
Science and engineering	NA	NA	NA	163	195	182	202	257	247	315	419	410
Natural sciences[a]	NA	NA	NA	45	49	44	38	66	58	73	125	123
Math and computer sciences	NA	NA	NA	56	49	67	84	91	69	116	116	124
Social sciences[b]	NA	NA	NA	51	70	59	68	79	106	118	160	142
Engineering	NA	NA	NA	11	27	12	12	21	14	8	18	21
Engineering technology	204	191	285	267	219	257	168	232	175	210	263	260
Foreign citizens												
All degrees	3,331	4,554	6,645	6,426	4,485	5,969	5,937	6,977	8,027	9,024	10,169	9,911
Science and engineering	NA	NA	NA	616	408	461	362	368	520	637	707	707
Natural sciences[a]	NA	NA	NA	74	81	97	75	73	109	138	157	177
Math and computer sciences	NA	NA	NA	313	177	205	169	171	251	284	282	298
Social sciences[b]	NA	NA	NA	73	30	76	48	56	80	137	179	156
Engineering	NA	NA	NA	156	120	83	70	68	80	78	89	76
Engineering technology	393	585	1,055	680	575	533	467	526	504	380	414	412

NA = not available

NOTES: Data on associate degrees are not available for broad science and engineering fields before 1983. Data by racial/ethnic group were collected on a biennial schedule until 1990. Data by racial/ethnic group are collected by broad field of study only; therefore, these data cannot be adjusted to the exact field taxonomies used by the National Science Foundation.

[a] Natural sciences here include physical, earth, atmospheric, oceanographic, biological, and agricultural sciences.

[b] Social sciences include psychology, sociology, and other social sciences.

SOURCES: National Center for Education Statistics, Earned Degrees and Completion Surveys (Washington, DC: 1995), unpublished tabulations, and National Science Foundation, Science Resources Studies Division, unpublished tabulations.

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Science & Engineering Indicators – 1998

Appendix table 2-20.
Earned bachelor's degrees, by field and sex: 1975-95

Field	1975	1977	1979	1981	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
All bachelor's degree recipients																	
All degrees	931,663	928,228	931,340	946,877	980,679	986,345	990,877	1,000,204	1,003,532	1,006,033	1,030,171	1,062,151	1,107,997	1,150,072	1,179,278	1,183,141	1,174,436
Science and engineering	313,555	303,798	303,162	306,792	317,875	324,483	332,422	335,460	331,526	322,482	322,821	329,094	337,675	355,265	366,035	373,261	378,148
Natural sciences	87,199	93,179	90,120	84,062	79,315	76,475	75,429	72,499	68,724	64,734	62,860	62,652	65,189	71,269	77,312	83,791	90,845
Physical	16,001	16,937	17,257	17,446	16,197	15,831	16,270	15,784	15,464	14,255	14,148	13,425	13,678	13,875	14,188	14,655	14,897
Earth/atm/ocean	4,877	5,653	6,082	6,694	7,298	7,925	7,576	6,076	4,689	3,554	3,181	2,776	2,728	3,201	3,503	3,868	4,478
Biological & agricultural	66,321	70,589	66,781	59,922	55,820	52,719	51,583	50,639	48,571	46,925	45,531	46,451	48,783	54,193	59,621	65,268	71,470
Math/computer sciences	23,385	20,729	20,670	26,406	37,239	45,777	54,388	58,583	56,442	50,877	46,277	42,369	40,194	39,889	39,433	39,185	38,620
Mathematics	18,346	14,303	11,901	11,173	12,557	13,342	15,267	16,388	16,515	15,981	15,314	14,674	14,784	14,931	14,853	14,632	13,851
Computer sciences	5,039	6,426	8,769	15,233	24,682	32,435	39,121	42,195	39,927	34,896	30,963	27,695	25,410	24,958	24,580	24,553	24,769
Social and behavioral sciences	163,147	148,533	138,903	132,607	128,651	126,078	125,033	127,558	131,935	136,717	146,737	159,368	170,105	182,166	186,585	187,273	185,312
Psychology	51,436	47,794	43,012	41,364	40,825	40,375	40,237	40,937	43,195	45,378	48,954	54,018	58,893	64,033	67,251	69,768	72,601
Social sciences	111,711	100,739	95,891	91,243	87,826	85,703	84,796	86,621	88,740	91,339	97,783	105,350	111,212	118,133	119,334	117,505	112,711
Engineering	39,824	41,357	53,469	63,717	72,670	76,153	77,572	76,820	74,425	70,154	66,947	64,705	62,187	61,941	62,705	63,012	63,371
Chemical engineering	3,420	3,986	6,442	7,639	8,550	9,192	8,941	7,411	6,114	4,654	4,187	3,834	3,728	4,123	4,899	5,636	6,391
Civil engineering	8,289	8,898	10,583	11,331	10,747	10,351	9,730	9,223	8,746	8,131	8,015	7,992	8,083	8,920	9,788	10,603	11,329
Electrical engineering	10,246	10,018	12,440	15,040	19,205	21,541	23,668	26,112	26,791	25,942	24,318	23,015	21,520	20,256	19,598	18,241	17,579
Industrial engineering	2,583	2,264	2,804	3,878	3,824	4,020	4,009	4,255	4,313	4,259	4,121	4,041	3,820	4,029	3,584	3,453	3,519
Mechanical engineering	7,089	7,927	10,360	13,573	16,031	17,040	17,200	16,586	15,723	15,331	15,217	14,693	14,263	14,352	14,708	15,297	15,141
Other engineering	8,197	8,264	10,840	12,256	14,313	14,009	14,024	13,233	12,738	11,837	11,089	11,130	10,773	10,261	10,128	9,782	9,412
Engineering technology	8,589	9,864	10,906	13,567	18,663	20,225	20,533	20,928	20,577	20,447	20,098	19,150	18,294	17,118	17,022	16,703	16,607
Males																	
All degrees	508,424	499,121	481,394	474,336	483,395	486,750	486,660	490,143	485,003	481,236	487,566	495,867	508,952	525,395	537,536	537,061	531,146
Science and engineering	210,741	198,805	193,247	190,977	194,538	199,262	203,464	204,771	199,981	191,549	189,338	189,082	189,328	195,779	200,315	202,284	202,217
Natural sciences	63,977	65,378	60,047	53,430	48,379	46,482	45,447	43,405	40,589	36,930	36,009	35,157	36,206	38,939	42,316	45,600	48,474
Physical	12,990	13,560	13,358	13,137	11,586	11,175	11,434	11,088	10,792	9,673	9,777	9,106	9,253	9,289	9,424	9,588	9,605
Earth/atm/ocean	4,050	4,479	4,695	5,028	5,450	5,991	5,715	4,722	3,629	2,707	2,380	2,001	1,946	2,177	2,453	2,665	2,954
Biological & agricultural	46,937	47,339	41,994	35,265	31,343	29,316	28,298	27,595	26,168	24,550	23,852	24,050	25,007	27,473	30,439	33,347	35,915
Math/computer sciences	14,729	13,241	13,249	16,672	22,749	27,797	32,921	35,841	34,871	32,112	29,682	27,184	25,700	25,693	25,483	25,397	25,066
Mathematics	10,646	8,354	6,943	6,392	7,059	7,428	8,231	8,772	8,833	8,569	8,264	7,863	7,804	7,945	7,854	7,864	7,360
Computer sciences	4,083	4,887	6,306	10,280	15,690	20,369	24,690	27,069	26,038	23,543	21,418	19,321	17,896	17,748	17,629	17,533	17,706
Social and behavioral sciences	93,056	80,873	71,363	64,221	60,392	59,559	58,770	59,843	61,500	63,132	66,888	72,009	74,900	78,842	79,792	78,678	76,256
Psychology	24,333	20,692	16,649	14,447	13,228	12,949	12,815	12,691	13,399	13,584	14,291	15,399	16,155	17,130	18,029	18,749	19,638
Social sciences	68,723	60,181	54,714	49,774	47,164	46,610	45,955	47,152	48,101	49,548	52,597	56,610	58,745	61,712	61,763	59,929	56,618
Engineering	38,979	39,313	48,588	56,654	63,018	65,424	66,326	65,682	63,021	59,375	56,759	54,732	52,522	52,305	52,724	52,609	52,421
Chemical engineering	3,273	3,534	5,387	6,274	6,761	7,115	6,848	5,805	4,574	3,522	3,017	2,745	2,564	2,854	3,335	3,953	4,367
Civil engineering	8,116	8,413	9,534	10,100	9,263	8,928	8,388	7,994	7,550	6,960	6,841	6,730	6,803	7,395	8,009	8,619	9,031
Electrical engineering	10,116	9,750	11,781	13,940	17,283	19,252	20,936	22,885	23,227	22,418	21,130	20,148	18,757	17,801	17,339	15,990	15,409
Industrial engineering	2,524	2,115	2,376	3,111	2,824	2,949	2,842	2,974	2,929	3,014	2,860	2,835	2,723	2,890	2,547	2,439	2,493
Mechanical engineering	7,005	7,685	9,740	12,422	14,546	15,228	15,399	14,876	13,996	13,567	13,537	12,978	12,673	12,791	13,076	13,554	13,441
Other engineering	7,945	7,816	9,770	10,807	12,341	11,952	11,913	11,148	10,745	9,894	9,374	9,296	9,002	8,574	8,418	8,054	7,680
Engineering technology	8,054	9,173	9,942	12,032	16,529	18,052	18,278	18,734	18,429	18,337	17,999	17,113	16,329	15,314	15,114	14,877	14,704

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Appendix table 2-20.

Earned bachelor's degrees, by field and sex: 1975-95

Field	1975	1977	1979	1981	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Females																	
All degrees	423,239	429,107	449,946	472,541	497,284	499,595	504,217	510,061	518,529	524,797	542,605	566,284	599,045	624,677	641,742	646,080	643,290
Science and engineering	102,814	104,993	109,915	115,815	123,337	125,221	128,958	130,689	131,545	130,933	133,483	140,012	148,347	159,486	165,720	170,977	175,931
Natural sciences	23,222	27,801	30,073	30,632	30,936	29,993	29,982	29,094	28,135	27,804	26,851	27,495	28,983	32,330	34,996	38,191	42,371
Physical	3,011	3,377	3,899	4,309	4,611	4,656	4,836	4,696	4,672	4,582	4,371	4,319	4,425	4,586	4,764	5,067	5,292
Earth/atm/ocean	827	1,174	1,387	1,666	1,848	1,934	1,861	1,354	1,060	847	801	775	782	1,024	1,050	1,203	1,524
Biological & agricultural	19,384	23,250	24,787	24,657	24,477	23,403	23,285	23,044	22,403	22,375	21,679	22,401	23,776	26,720	29,182	31,921	35,555
Math/computer sciences	8,656	7,488	7,421	9,734	14,490	17,980	21,467	22,742	21,571	18,765	16,595	15,185	14,494	14,196	13,950	13,788	13,554
Mathematics	7,700	5,949	4,958	4,781	5,498	5,914	7,036	7,616	7,682	7,412	7,050	6,811	6,980	6,986	6,999	6,768	6,491
Computer sciences	956	1,539	2,463	4,953	8,992	12,066	14,431	15,126	13,889	11,353	9,545	8,374	7,514	7,210	6,951	7,020	7,063
Social and behavioral sciences	70,091	67,660	67,540	68,386	68,259	66,519	66,263	67,715	70,435	73,585	79,849	87,359	95,205	103,324	106,793	108,595	109,056
Psychology	27,103	27,102	26,363	26,917	27,597	27,426	27,422	28,246	29,796	31,794	34,663	38,619	42,738	46,903	49,222	51,019	52,963
Social sciences	42,988	40,558	41,177	41,469	40,662	39,093	38,841	39,469	40,639	41,791	45,186	48,740	52,467	56,421	57,571	57,576	56,093
Engineering	845	2,044	4,881	7,063	9,652	10,729	11,246	11,138	11,404	10,779	10,188	9,973	9,665	9,636	9,981	10,403	10,950
Chemical engineering	147	452	1,055	1,365	1,789	2,077	2,093	1,606	1,540	1,132	1,170	1,089	1,164	1,269	1,564	1,683	2,024
Civil engineering	173	485	1,049	1,231	1,484	1,423	1,342	1,229	1,196	1,171	1,174	1,262	1,280	1,525	1,779	1,984	2,298
Electrical engineering	130	268	659	1,100	1,922	2,289	2,732	3,227	3,564	3,524	3,188	2,867	2,763	2,455	2,259	2,251	2,170
Industrial engineering	59	149	428	767	1,000	1,071	1,167	1,281	1,384	1,245	1,261	1,206	1,097	1,139	1,037	1,014	1,026
Mechanical engineering	84	242	620	1,151	1,485	1,812	1,801	1,710	1,727	1,764	1,680	1,715	1,590	1,561	1,632	1,743	1,700
Other engineering	252	448	1,070	1,449	1,972	2,057	2,111	2,065	1,993	1,943	1,715	1,834	1,771	1,687	1,710	1,728	1,732
Engineering technology	535	691	964	1,533	2,134	2,173	2,255	2,194	2,148	2,110	2,099	2,037	1,965	1,804	1,908	1,826	1,903

SOURCES: National Center for Education Statistics, Earned Degrees and Completion Surveys (Washington, DC: 1995), unpublished tabulations; and National Science Foundation, Science Resources Studies Division, unpublished tabulations.

See figures 2-11 and 2-12 and text table 2-5.

Appendix table 2-21.
Earned bachelor's degrees, by field, race/ethnicity, and citizenship: 1977-95

Field and race/ethnicity	1977	1979	1981	1985	1987	1989	1991	1993	1994	1995
Total										
All degrees	928,228	931,340	946,877	990,877	1,003,532	1,030,171	1,107,997	1,179,278	1,183,141	1,174,436
Science and engineering	337,834	334,632	337,739	342,970	343,070	337,431	356,785	388,435	395,380	399,809
Natural sciences[a]	98,342	96,186	90,254	75,670	68,929	63,073	65,401	77,395	83,903	91,026
Math and computer sciences	20,729	20,670	26,406	54,388	56,442	46,277	40,194	39,347	38,889	38,421
Social sciences[b]	169,086	154,976	145,684	135,341	143,276	161,134	189,004	209,023	209,626	207,032
Engineering	49,677	62,800	75,395	77,571	74,423	66,947	62,186	62,670	62,962	63,330
Engineering technology	NA	NA	NA	20,533	20,577	20,098	18,294	16,987	16,654	16,542
U.S. citizens and permanent residents										
All degrees	910,835	911,637	923,906	950,118	948,563	980,064	1,052,610	1,122,276	1,123,862	1,110,512
Science and engineering	329,351	324,750	324,724	325,172	319,963	317,950	335,424	366,357	372,858	375,745
Natural sciences[a]	96,268	94,101	88,001	72,860	65,632	60,423	62,117	73,571	80,096	86,688
Math and computer sciences	20,138	19,926	25,172	50,904	51,449	42,245	36,549	35,864	35,283	34,709
Social sciences[b]	166,852	152,720	143,165	131,499	135,722	154,321	180,423	199,948	200,256	197,120
Engineering	46,093	58,003	68,386	69,909	67,160	60,961	56,335	56,974	57,223	57,228
Engineering technology	NA	NA	NA	19,120	19,359	18,942	17,080	16,109	16,161	15,992
White, all degrees	807,857	802,665	807,509	826,356	819,477	840,326	892,363	931,603	918,124	892,785
Science and engineering	292,802	287,126	284,166	281,394	272,090	266,862	278,190	297,171	297,616	294,773
Natural sciences[a]	88,308	85,403	78,778	63,592	55,898	50,580	51,113	59,577	64,291	68,700
Math and computer sciences	18,110	17,633	22,013	43,484	42,446	33,998	28,998	27,824	26,905	25,875
Social sciences[b]	144,312	131,439	122,519	113,326	117,255	132,203	152,917	164,917	161,733	156,472
Engineering	42,072	52,651	60,856	60,992	56,491	50,081	45,162	44,853	44,687	43,726
Engineering technology	NA	NA	NA	16,673	16,541	16,156	14,279	13,245	12,909	12,616
Asian, all degrees	13,907	15,542	18,908	25,562	31,921	37,573	41,725	50,587	54,675	59,295
Science and engineering	6,203	7,171	9,145	13,323	16,934	19,138	20,552	24,504	26,420	29,128
Natural sciences[a]	1,935	2,227	2,406	2,880	3,641	3,973	4,670	6,364	7,228	8,677
Math and computer sciences	479	587	1,061	2,929	3,489	3,287	2,925	3,160	3,173	3,330
Social sciences[b]	2,578	2,499	2,612	3,032	4,214	5,803	6,737	8,573	9,503	10,336
Engineering	1,211	1,858	3,066	4,482	5,590	6,075	6,220	6,407	6,516	6,785
Engineering technology	0	0	0	542	807	839	768	768	720	727
Black, all degrees	58,700	60,301	60,729	57,563	55,103	56,837	65,009	76,667	82,316	85,287
Science and engineering	19,552	18,827	18,895	17,040	17,230	17,385	19,987	24,421	26,289	27,528
Natural sciences[a]	3,416	3,541	3,561	3,096	2,870	2,756	3,026	3,794	4,169	4,528
Math and computer sciences	1,073	1,159	1,371	2,913	3,654	3,249	2,808	3,178	3,390	3,493
Social sciences[b]	13,678	12,352	11,514	8,992	8,391	9,313	11,924	14,872	16,071	16,662
Engineering	1,385	1,775	2,449	2,039	2,315	2,067	2,229	2,577	2,659	2,845
Engineering technology	0	0	0	1,277	1,269	1,208	1,227	1,132	1,249	1,319
Hispanic, all degrees	27,043	29,719	33,167	36,391	38,196	41,361	49,027	57,845	62,683	66,691
Science and engineering	9,628	10,432	11,312	12,031	12,419	13,327	15,351	18,442	20,529	22,190
Natural sciences[a]	2,271	2,634	2,958	2,979	2,964	2,849	3,010	3,468	3,970	4,276
Math and computer sciences	435	495	688	1,380	1,696	1,568	1,695	1,566	1,678	1,843
Social sciences[b]	5,632	5,748	5,846	5,485	5,205	6,349	8,080	10,447	11,738	12,420
Engineering	1,290	1,555	1,820	2,187	2,554	2,561	2,566	2,961	3,143	3,651
Engineering technology	0	0	0	525	664	634	731	853	813	883
Native American, all degrees	3,328	3,410	3,593	4,246	3,866	3,967	4,486	5,574	6,064	6,454
Science and engineering	1,166	1,194	1,206	1,384	1,290	1,238	1,344	1,819	2,004	2,126
Natural sciences[a]	338	296	298	313	259	265	298	368	438	507
Math and computer sciences	41	52	39	198	164	143	123	136	137	168
Social sciences[b]	652	682	674	664	657	653	765	1,139	1,211	1,230
Engineering	135	164	195	209	210	177	158	176	218	221
Engineering technology	0	0	0	103	78	105	75	111	98	115

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Appendix table 2-21.

Earned bachelor's degrees, by field, race/ethnicity, and citizenship: 1977-95

Field and race/ethnicity	1977	1979	1981	1985	1987	1989	1991	1993	1994	1995
					Foreign citizens					
All degrees	15,744	17,853	22,631	29,258	28,592	26,457	29,657	32,371	34,227	37,012
Science and engineering	8,297	9,798	12,966	14,071	13,677	12,323	12,724	13,802	13,929	14,754
Natural sciences[a]	2,042	2,061	2,251	2,132	1,786	1,744	1,941	2,330	2,114	2,262
Math and computer sciences	583	741	1,233	2,879	3,233	2,678	2,615	2,756	2,835	2,888
Social sciences[b]	2,098	2,232	2,519	2,870	2,769	2,829	3,586	4,211	4,440	4,794
Engineering	3,574	4,764	6,963	6,190	5,889	5,072	4,582	4,505	4,540	4,810
Engineering technology	NA	NA	NA	1,277	986	659	712	441	493	550

NA = not available

NOTES: Data by racial/ethnic group were collected on a biennial schedule until 1990 and annually thereafter. Data by racial/ethnic group are collected by broad fields of study only; therefore, these data cannot be adjusted to the exact field taxonomies used by the National Science Foundation.

[a] Natural sciences here include physical, earth, atmospheric, oceanographic, biological, and agricultural sciences.

[b] Social sciences include psychology, sociology, and other social sciences.

SOURCE: National Science Foundation, Science Resources Studies Division, *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1977-94, NSF 96-329* (Arlington, VA: 1996).

See text table 2-5.

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Science & Engineering Indicators – 1998

Appendix table 2-22.

Semesters of postsecondary math courses taken, by type of college and major: 1991-94

(Percentages)

Postsecondary education/major	Number of math courses taken: 0	1 to 2	3 to 4	5 +	Median	N
Total	16	47	28	9	2	1,530
Some community college education	34	50	14	2	1	352
Some college/university education	16	59	24	2	2	316
Associate degree	26	46	21	7	2	121
Bachelor's degree	7	41	37	15	3	741
Students with some community college education						
Science, math, engineering, or other technical	15	35	44	6	2	48
Health	21	56	19	4	1	52
Social science	41	47	12	0	1	17
Education	17	53	27	3	2	30
Other major	18	62	15	5	2	137
Not reported/no major	50	42	7	1	0	191
Students with some college/university education						
Science, math, engineering, or other technical	3	40	44	13	3	40
Health	11	59	27	3	2	37
Social science	6	75	16	3	2	32
Education	23	54	23	0	2	22
Other major	12	60	27	1	2	102
Not reported/no major	29	61	9	0	1	85
Students with bachelor's degree or higher						
Science	1	39	45	15	3	78
Math, engineering, or other technical	2	8	37	53	5	87
Health	7	44	36	13	2	62
Social science	7	52	33	8	2	121
Education	5	34	51	10	3	88
Other major	9	48	33	10	2	298

NOTES: Only respondents enrolled in or graduated from a community college, college, or university degree program are included in this analysis. Respondents who are not in any educational program, are still in high school or a GED program, or are in a vocational or trade school program are not included. The four categories of postsecondary education are (1) some community college education (but no degree), (2) some college or university education (but no degree), (3) associate degree, and (4) bachelor's degree or higher. Postsecondary education data from the Longitudinal Study of American Youth were collected during years four (1991), five (1992), and seven (1994) of the study. Those data collection points represent the first, second, and fourth postsecondary years. Thus, a student who graduated from high school in the usual time sequence could have completed a baccalaureate at the time of the last data collection point.

SOURCE: J.D. Miller, Longitudinal Study of American Youth, special tabulations, 1997.

Science & Engineering Indicators – 1998

Appendix table 2-23.

Semesters of postsecondary science courses taken, by type of college and major: 1991-94

(Percentages)

Postsecondary education/major	Number of science courses taken					
	0	1 to 2	3 to 4	5 +	Median	N
Total	25	31	23	21	2	1,529
Some community college education	55	27	13	5	0	352
Some college/university education	30	40	19	11	1	315
Associate degree	39	30	18	13	2	120
Bachelor's degree	6	31	30	33	3	742
Students with some community college education						
Science, math, engineering, or other technical	30	26	33	11	2	47
Health	16	33	20	31	3	51
Social science	35	29	24	12	2	17
Education	30	43	24	3	2	33
Other major	58	27	13	2	0	137
Not reported/no major	66	25	6	3	0	189
Students with some college/university education						
Science, math, engineering, or other technical	15	28	32	25	3	40
Health	8	29	24	39	4	38
Social science	24	38	38	0	2	29
Education	29	47	14	10	2	21
Other major	27	53	15	5	1	101
Not reported/no major	51	33	11	5	0	87
Students with bachelor's degree or higher						
Science	0	3	5	92	10	79
Math, engineering, or other technical	5	17	30	48	4	86
Health	0	6	15	79	7	62
Social science	7	33	37	23	3	120
Education	2	29	43	26	3	89
Other major	8	47	33	12	2	298

NOTES: Only respondents enrolled in or graduated from a community college, college, or university degree program are included in this analysis. Respondents who are not in any educational program, are still in high school or a GED program, or are in a vocational or trade school program are not included. The four categories of postsecondary education are (1) some community college education (but no degree), (2) some college or university education (but no degree), (3) associate degree, and (4) bachelor's degree or higher. Postsecondary education data from the Longitudinal Study of American Youth were collected during years four (1991), five (1992), and seven (1994) of the study. Those data collection points represent the first, second, and fourth postsecondary years. Thus, a student who graduated from high school in the usual time sequence could have completed a baccalaureate at the time of the last data collection point.

SOURCE: J.D. Miller, Longitudinal Study of American Youth, special tabulations, 1997.

Science & Engineering Indicators – 1998

Appendix table 2-24.

Graduate enrollment in science and engineering, by field and sex: 1975-95

Field	1975	1977	1979	1981	1983	1985	1987	1988	1989	1990	1991	1992	1993	1994	1995
						Total									
Science & engineering	303,190	311,816	319,171	332,086	347,065	358,126	373,355	375,287	382,769	397,159	412,708	430,797	436,233	431,758	423,922
Natural sciences[a]	95,489	101,221	100,871	100,617	102,979	104,074	104,963	105,529	107,301	109,364	112,474	116,699	119,489	120,833	120,451
Math & computer sciences	25,307	25,160	26,721	32,318	40,691	47,332	50,559	51,304	51,729	54,031	54,562	56,675	56,298	53,857	52,018
Social sciences[b]	119,851	114,716	112,652	121,462	116,538	110,515	111,412	113,880	115,625	119,696	126,139	132,096	139,388	143,565	144,008
Engineering	68,271	68,685	71,728	79,555	91,119	95,991	103,953	102,829	104,043	107,625	113,576	118,035	116,881	113,060	107,529
						Males									
Science & engineering	NA	233,862	229,860	232,209	240,525	247,464	256,158	254,011	256,861	263,407	271,853	280,465	279,476	272,420	263,058
Natural sciences[a]	0	76,073	72,945	70,721	70,711	70,745	70,685	69,869	70,263	70,800	71,753	73,754	74,086	73,878	72,591
Math & computer sciences	0	19,482	20,376	23,628	28,877	34,417	36,948	37,334	37,756	39,633	39,994	41,659	41,188	39,170	37,582
Social sciences[b]	0	73,322	70,687	66,051	59,625	57,391	57,535	57,103	58,399	60,021	62,245	64,250	65,013	64,366	63,508
Engineering	NA	64,985	65,852	71,809	81,312	84,911	90,990	89,705	90,443	92,953	97,861	100,802	99,189	95,006	89,377
						Females									
Science & engineering	NA	77,954	89,311	99,877	106,540	110,662	117,197	121,276	125,908	133,752	140,855	150,332	156,757	159,338	160,864
Natural sciences[a]	0	25,148	27,926	29,896	32,268	33,329	34,278	35,660	37,038	38,564	40,721	42,945	45,403	46,955	47,860
Math & computer sciences	0	5,678	6,345	8,690	11,814	12,915	13,611	13,970	13,973	14,398	14,568	15,016	15,110	14,687	14,436
Social sciences[b]	0	43,428	49,164	53,545	52,651	53,338	56,345	58,522	61,297	66,118	69,851	75,138	78,552	79,642	80,416
Engineering	NA	3,700	5,876	7,746	9,807	11,080	12,963	13,124	13,600	14,672	15,715	17,233	17,692	18,054	18,152

NA = not available

NOTE: For detailed statistical tables on graduate enrollments, see SRS home page <<http://www.nsf.gov/sbe/srs/stats.htm>>, Fall 1995 Supplementary Data Releases: Trends in Graduate Enrollment, 1975-1995.

[a] Natural sciences here include physical, earth, atmospheric, oceanographic, biological, and agricultural sciences.

[b] Social sciences include psychology, sociology, and other social sciences.

SOURCE: National Science Foundation, Science Resources Studies Division, *Graduate Students and Postdoctorates in Science and Engineering, Fall 1995*, NSF 97-312 (Arlington, VA: 1997).

See figures 2-13 and 2-14.

Science & Engineering Indicators – 1998

Appendix table 2-25.

Graduate enrollment in science and engineering, by field, race/ethnicity, and citizenship: 1983-95

Field and race/ethnicity	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Total													
Science & engineering	347,014	349,875	358,201	368,212	373,425	375,287	382,769	397,159	412,708	430,797	436,233	431,758	423,922
Natural sciences[a]	102,968	103,547	103,990	105,541	104,974	105,529	107,301	109,364	112,474	116,699	119,489	120,833	120,451
Math & computer sciences	40,713	42,985	47,341	49,316	50,575	51,304	51,729	54,031	54,562	56,675	56,298	53,857	52,018
Social sciences[b]	112,236	110,647	110,808	111,499	113,939	115,625	119,696	126,139	132,096	139,388	143,565	144,008	143,924
Engineering	91,097	92,696	95,982	101,856	103,937	102,829	104,043	107,625	113,576	118,035	116,881	113,060	107,529
U.S. citizens													
Total S&E	276,784	277,682	281,388	284,231	284,631	281,672	284,686	294,339	304,073	321,281	330,447	329,391	325,135
Natural sciences[a]	84,700	84,712	83,663	82,854	80,562	79,431	79,242	79,521	81,148	84,893	88,164	89,852	90,653
Math & computer sciences	30,306	31,532	34,499	35,448	35,669	35,895	35,352	36,561	36,306	38,043	38,210	36,696	35,484
Social sciences[b]	98,173	96,644	95,978	96,018	97,831	98,743	102,746	108,831	114,386	121,750	126,459	126,778	126,956
Engineering	63,605	64,794	67,160	69,911	70,569	67,603	67,346	69,426	72,233	76,595	77,614	76,065	72,042
White, S&E	224,705	224,705	224,705	224,705	224,705	229,037	229,694	238,492	243,608	253,516	257,009	255,976	246,776
Natural sciences[a]	74,337	74,046	71,971	71,713	69,100	68,737	68,110	68,736	69,472	71,328	72,552	74,134	73,332
Math & computer sciences	23,823	24,040	25,511	26,053	26,806	27,479	26,560	27,897	26,921	27,745	27,373	26,245	24,425
Social sciences[b]	77,963	75,787	76,129	76,930	79,157	80,492	83,531	88,652	92,431	97,047	99,633	99,566	96,906
Engineering	48,582	48,582	48,582	48,582	48,582	52,329	51,493	53,207	54,784	57,396	57,451	56,031	52,113
Asian, S&E	9,353	10,172	12,000	12,775	14,572	15,188	15,693	17,156	18,139	21,762	24,149	26,457	26,015
Natural sciences[a]	2,378	2,526	2,712	2,761	3,043	3,478	3,604	3,928	4,267	5,035	6,162	6,568	6,740
Math & computer sciences	1,666	1,816	2,491	2,770	3,235	3,438	3,430	3,710	3,724	4,363	4,592	5,302	5,227
Social sciences[b]	1,903	2,018	1,992	2,130	2,436	2,362	2,648	2,831	3,032	3,872	4,396	4,786	4,930
Engineering	3,406	3,812	4,805	5,114	5,858	5,910	6,011	6,687	7,116	8,492	8,999	9,801	9,118
Black, S&E	10,903	10,711	10,462	10,470	10,429	11,191	11,775	12,774	13,691	15,449	17,147	17,665	18,366
Natural sciences[a]	1,980	2,000	1,982	1,845	1,817	1,972	2,093	2,184	2,302	2,711	3,042	3,007	3,286
Math & computer sciences	971	960	1,031	1,151	1,210	1,261	1,311	1,496	1,617	1,687	1,903	1,888	1,879
Social sciences[b]	6,574	6,306	6,062	6,022	5,986	6,458	6,755	7,308	7,747	8,677	9,643	9,987	10,329
Engineering	1,378	1,445	1,387	1,452	1,416	1,500	1,616	1,786	2,025	2,374	2,559	2,783	2,872
Hispanic, S&E	8,811	8,681	8,613	8,660	8,823	9,098	9,436	10,159	11,045	12,248	13,386	13,284	14,089
Natural sciences[a]	1,919	1,892	2,092	2,118	2,071	2,228	2,386	2,375	2,552	2,726	3,075	2,933	3,200
Math & computer sciences	615	585	750	723	817	844	847	916	980	1,082	1,114	1,006	1,060
Social sciences[b]	4,836	4,713	4,290	4,217	4,205	4,307	4,496	4,982	5,389	5,977	6,503	6,488	6,998
Engineering	1,441	1,491	1,481	1,602	1,730	1,719	1,707	1,886	2,124	2,463	2,694	2,857	2,831
Native American S&E	911	830	736	743	783	918	860	1,054	1,120	1,244	1,312	1,383	1,524
Natural sciences[a]	224	206	167	196	183	216	180	255	251	282	318	336	403
Math & computer sciences	53	71	79	52	76	71	74	64	62	99	100	79	125
Social sciences[b]	454	361	368	365	401	488	484	583	622	686	683	726	765
Engineering	180	192	122	130	123	143	122	152	185	177	211	242	231
Unknown, S&E	22,101	24,179	25,825	23,961	21,160	16,240	17,228	14,704	16,470	17,062	17,444	14,626	18,365
Natural sciences[a]	3,862	4,042	4,819	4,221	4,348	2,800	2,869	2,043	2,304	2,811	3,015	2,874	3,692
Math & computer sciences	3,178	4,060	4,637	4,699	3,525	2,802	3,130	2,478	3,002	3,067	3,128	2,176	2,768
Social sciences[b]	6,443	7,459	7,145	6,354	5,646	4,636	4,832	4,475	5,165	5,491	5,601	5,225	7,028
Engineering	8,618	8,618	9,224	8,687	7,641	6,002	6,397	5,708	5,999	5,693	5,700	4,351	4,877

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Appendix table 2-25.

Graduate enrollment in science and engineering, by field, race/ethnicity, and citizenship: 1983-95

Field and race/ethnicity	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Foreign citizens													
Total S&E	70,230	72,193	76,813	83,981	88,794	93,615	98,083	102,820	108,635	109,516	105,786	102,367	98,787
Natural sciences[a]	18,268	18,835	20,327	22,687	24,412	26,098	28,059	29,843	31,326	31,806	31,325	30,981	29,798
Math & computer sciences	10,407	11,453	12,842	13,868	14,906	15,409	16,377	17,470	18,256	18,632	18,088	17,161	16,534
Social sciences[b]	14,063	14,003	14,830	15,481	16,108	16,882	16,950	17,308	17,710	17,638	17,106	17,230	16,968
Engineering	27,492	27,902	28,822	31,945	33,368	35,226	36,697	38,199	41,343	41,440	39,267	36,995	35,487

NOTE: For detailed statistical tables on graduate enrollments, see SRS home page <<http://www.nsf.gov/sbe/srs/stats.htm>>, Fall 1995 Supplementary Data Releases: Trends in Graduate Enrollment, 1975-1995.

[a] Natural sciences here include physical, earth, atmospheric, oceanographic, biological, and agricultural sciences.

[b] Social sciences include psychology, sociology, and other social sciences.

SOURCE: National Science Foundation, Science Resources Studies Division, *Graduate Students and Postdoctorates in Science and Engineering Fall 1995*, NSF 97-312 (Arlington, VA: 1997).

See figure 2-14.

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Appendix table 2-26.

Doctoral degrees awarded in science and engineering in selected Asian countries: 1975-95

Country	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Natural sciences[a]																					
Total	2,162	2,399	2,706	2,863	3,120	3,268	3,390	3,523	3,665	3,899	4,017	3,992	4,015	4,326	4,295	4,237	4,381	4,547	5,141	5,752	6,304
China	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	33	27	52	165	141	209	252	304	479	755	1,191
India	1,484	1,651	1,837	2,044	2,261	2,385	2,516	2,654	2,800	2,954	2,892	2,922	2,814	3,038	3,044	2,976	2,950	2,950	3,386	3,505	3,505
Japan	676	717	843	782	814	822	791	762	774	807	860	820	837	881	876	835	892	1,009	934	1,081	1,135
S. Korea	NA	29	22	30	41	55	75	102	83	124	212	201	277	207	192	170	225	202	244	296	358
Taiwan	2	2	4	7	4	6	8	5	8	14	20	22	35	35	42	47	62	82	97	115	115
Mathematics and computer sciences																					
Total	0	0	0	0	1	1	1	3	4	2	27	23	45	162	201	188	226	249	169	194	224
China	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	23	10	31	75	78	89	95	101	0	0	NA
India	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Japan	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
S. Korea	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	73	105	75	99	106	124	145	169
Taiwan	0	0	0	0	1	1	1	3	4	2	4	13	14	14	18	24	32	42	45	49	55
Agriculture																					
Total	674	870	934	912	962	1,098	1,153	1,185	1,240	1,404	1,372	1,355	1,444	1,696	1,689	1,629	1,814	1,797	1,742	1,911	2,048
China	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	0	8	55	56	20	37	68	94	131	182
India	289	328	372	422	480	517	558	601	648	698	575	576	583	712	688	703	715	715	611	572	572
Japan	381	490	518	442	430	527	529	521	515	614	697	646	715	746	734	719	870	824	816	952	1,008
S. Korea	NA	48	40	43	45	48	52	55	60	77	89	105	110	155	175	154	156	151	172	196	223
Taiwan	4	4	4	5	7	5	15	8	17	15	10	28	28	28	36	33	36	39	48	60	63
Social sciences[b]																					
Total	91	123	124	113	106	108	111	131	153	152	193	215	273	305	338	369	467	544	597	695	775
China	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	1	0	26	23	36	47	61	90	134	198
India	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Japan	84	85	88	88	76	76	76	93	97	90	127	136	149	167	177	183	200	243	249	278	301
S. Korea	NA	31	23	23	24	24	25	25	41	39	50	52	102	90	97	107	189	217	222	227	232
Taiwan	7	7	13	2	6	8	10	13	15	23	16	26	22	22	41	43	31	23	36	56	44
Engineering																					
Total	1,130	1,242	1,195	1,323	1,408	1,417	1,494	1,566	1,590	1,634	2,239	2,447	2,645	3,212	3,621	3,860	4,165	4,630	4,586	5,260	6,327
China	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	68	89	127	476	726	715	767	823	1,040	1,313	1,659
India	136	135	135	134	176	179	182	185	189	192	511	509	603	575	586	574	629	629	323	348	348
Japan	986	1,079	1,043	1,166	1,195	1,186	1,236	1,278	1,290	1,291	1,404	1,493	1,547	1,717	1,774	1,967	2,094	2,362	2,278	2,501	3,009
S. Korea	NA	20	14	20	29	42	60	87	97	120	197	273	270	346	415	439	466	552	659	786	938
Taiwan	8	8	3	3	8	10	15	15	14	31	59	83	98	98	120	165	209	264	287	312	373

[a] Natural sciences here include physical, earth, atmospheric, oceanographic, and biological sciences.

[b] Social sciences include psychology, sociology, and other social sciences. Japanese social science data also include business administration.

SOURCES: **China**—National Research Center for Science and Technology for Development, unpublished tabulations, and UNESCO, *Statistical Yearbook* (Paris: 1996); **India**—Department of Science and Technology, *Research and Development Statistics 1994-95* (New Delhi: 1996); **Japan**—Ministry of Education, Science, and Culture (Monbusho), *Monbusho Survey of Education* (Tokyo: annual series); **South Korea**—Ministry of Education, *Statistical Yearbook of Education* (Seoul: 1996); and **Taiwan**—Ministry of Education, *Educational Statistics of the Republic of China* (Taipei: 1996).

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Appendix table 2-27.

Earned master's degrees, by field and sex: 1975-95

Field	1975	1977	1979	1981	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Total master's degree recipients																	
All degrees	293,651	318,241	302,075	296,798	290,931	285,462	287,213	289,829	290,532	300,091	311,050	324,947	338,498	354,207	370,973	389,008	399,428
Science and engineering	63,198	67,397	64,226	64,366	67,716	68,564	70,562	71,831	72,603	73,655	76,425	77,788	78,368	81,107	86,425	91,411	94,309
Natural sciences	14,831	15,360	15,443	14,349	14,380	14,231	13,972	13,910	13,400	13,184	13,218	12,928	12,682	13,232	13,474	14,367	14,793
Physical	4,298	3,641	3,650	3,366	3,285	3,544	3,605	3,649	3,574	3,708	3,876	3,805	3,777	3,922	3,965	4,263	4,241
Earth/atm/ocean	1,503	1,659	1,777	1,876	1,959	1,982	2,160	2,234	2,051	1,920	1,819	1,596	1,499	1,425	1,397	1,418	1,483
Biological & agricultural	9,030	10,060	10,016	9,107	9,136	8,705	8,207	8,027	7,775	7,556	7,523	7,527	7,406	7,885	8,112	8,686	9,069
Math/computer sciences	6,637	6,496	6,101	6,787	8,160	8,939	9,989	11,241	11,808	12,600	12,829	13,327	12,956	13,320	14,100	14,350	14,495
Mathematics	4,338	3,698	3,046	2,569	2,839	2,749	2,888	3,171	3,327	3,434	3,430	3,684	3,632	3,665	3,751	3,804	3,932
Computer sciences	2,299	2,798	3,055	4,218	5,321	6,190	7,101	8,070	8,481	9,166	9,399	9,643	9,324	9,655	10,349	10,546	10,563
Social & behavioral sciences	26,563	29,529	27,403	26,779	26,290	25,249	25,629	25,584	25,325	25,145	26,635	27,538	28,717	29,537	31,187	33,977	36,391
Psychology	7,104	8,320	8,031	8,039	8,439	8,073	8,481	8,363	8,165	7,925	8,652	9,308	9,802	9,852	10,412	11,572	13,132
Social sciences	19,459	21,209	19,372	18,740	17,851	17,176	17,148	17,221	17,160	17,220	17,983	18,230	18,915	19,685	20,775	22,405	23,259
Engineering	15,167	16,012	15,279	16,451	18,886	20,145	20,972	21,096	22,070	22,726	23,743	23,995	24,013	25,018	27,664	28,717	28,630
Chemical engineering	1,078	1,179	1,276	1,406	1,545	1,798	1,814	1,641	1,386	1,322	1,321	1,205	1,025	1,145	1,220	1,287	1,369
Civil engineering	3,268	3,606	3,165	3,428	3,504	3,551	3,542	3,281	3,267	3,134	3,296	3,213	3,404	3,755	4,438	4,918	5,168
Electrical engineering	3,471	3,788	3,596	3,902	4,819	5,519	5,649	6,147	6,895	7,455	7,849	8,009	7,942	8,274	8,828	8,870	8,743
Industrial engineering	1,687	1,609	1,502	1,631	1,432	1,557	1,463	1,653	1,728	1,816	1,823	1,834	2,039	2,370	2,745	2,882	2,873
Mechanical engineering	2,032	2,094	2,012	2,419	2,683	2,964	3,272	3,256	3,380	3,513	3,703	3,630	3,680	3,826	4,169	4,277	4,368
Other engineering	3,631	3,736	3,728	3,665	4,903	4,756	5,232	5,118	5,414	5,486	5,751	6,104	5,923	5,648	6,264	6,483	6,109
Engineering technology	371	505	496	532	622	694	816	925	883	980	1,135	1,194	1,188	1,278	1,555	1,547	1,577
Males																	
All degrees	162,115	168,210	153,772	147,431	145,114	143,998	143,716	143,932	141,655	145,403	149,399	154,025	156,895	162,299	169,753	176,762	179,198
Science and engineering	49,410	50,899	46,614	45,505	46,718	47,033	48,232	48,611	48,759	49,820	50,845	51,230	50,441	52,157	55,454	57,970	58,518
Natural sciences	11,709	11,633	11,223	10,222	9,814	9,513	9,290	9,133	8,652	8,562	8,383	8,052	7,794	8,118	8,181	8,539	8,730
Physical	3,645	2,981	2,971	2,691	2,600	2,698	2,775	2,736	2,684	2,817	2,836	2,754	2,703	2,834	2,794	3,030	2,958
Earth/atm/ocean	1,309	1,433	1,467	1,470	1,515	1,517	1,639	1,717	1,531	1,433	1,337	1,218	1,116	1,057	1,006	994	1,032
Biological & agricultural	6,755	7,219	6,785	6,061	5,699	5,298	4,876	4,680	4,437	4,312	4,210	4,080	3,975	4,227	4,381	4,515	4,740
Math/computer sciences	4,871	4,730	4,469	4,939	5,672	6,174	6,941	7,713	8,011	8,759	8,833	9,176	8,709	9,199	9,773	10,128	10,130
Mathematics	2,910	2,398	1,989	1,692	1,859	1,795	1,877	2,055	2,026	2,057	2,060	2,208	2,146	2,219	2,219	2,311	2,353
Computer sciences	1,961	2,332	2,480	3,247	3,813	4,379	5,064	5,658	5,985	6,702	6,773	6,968	6,563	6,980	7,554	7,817	7,777
Social & behavioral sciences	18,035	19,222	16,580	15,222	14,101	13,301	13,273	13,069	12,796	12,581	12,968	13,276	13,282	13,491	13,930	15,009	15,660
Psychology	4,059	4,316	3,688	3,371	3,254	2,980	3,064	2,937	2,838	2,599	2,814	3,025	2,994	2,929	2,928	3,287	3,735
Social sciences	13,976	14,906	12,892	11,851	10,847	10,321	10,209	10,132	9,958	9,982	10,154	10,251	10,288	10,562	11,002	11,722	11,925
Engineering	14,795	15,314	14,342	15,122	17,131	18,045	18,728	18,696	19,300	19,918	20,661	20,726	20,656	21,349	23,570	24,294	23,998
Chemical engineering	1,051	1,110	1,156	1,230	1,369	1,590	1,529	1,401	1,143	1,107	1,092	1,013	852	914	996	1008	1063
Civil engineering	3,161	3,421	2,951	3,112	3,122	3,136	3,128	2,908	2,792	2,721	2,851	2,693	2,864	3,120	3,607	3,965	4,123
Electrical engineering	3,413	3,654	3,453	3,681	4,484	5,081	5,154	5,508	6,178	6,642	6,933	7,018	7,008	7,229	7,777	7,721	7,539
Industrial engineering	1,631	1,534	1,374	1,465	1,226	1,279	1,236	1,374	1,409	1,492	1,465	1,493	1,603	1,898	2,190	2,346	2,361
Mechanical engineering	2,012	2,039	1,939	2,292	2,517	2,765	3,044	3,002	3,133	3,218	3,377	3,276	3,320	3,455	3,769	3,860	3,918
Other engineering	3,527	3,556	3,469	3,342	4,413	4,194	4,637	4,503	4,645	4,738	4,943	5,233	5,009	4,733	5,231	5,394	4,994
Engineering technology	281	389	371	380	519	580	674	710	678	738	892	888	888	971	1,172	1,164	1,136

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Appendix table 2-27.

Earned master's degrees, by field and sex: 1975–95

Field	1975	1977	1979	1981	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Females																	
All degrees	131,536	150,031	148,303	149,367	145,817	141,464	143,497	145,897	148,877	154,688	161,651	170,922	181,603	191,908	201,220	212,246	220,230
Science and engineering	13,788	16,498	17,612	18,861	20,998	21,531	22,330	23,220	23,844	23,835	25,580	26,558	27,927	28,950	30,971	33,441	35,791
Natural sciences	3,122	3,727	4,220	4,127	4,566	4,718	4,682	4,777	4,748	4,622	4,835	4,876	4,888	5,114	5,293	5,828	6,063
Physical	653	660	679	675	685	846	830	913	890	891	1,040	1,051	1,074	1,088	1,171	1,233	1,283
Earth/atm/ocean	194	226	310	406	444	465	521	517	520	487	482	378	383	368	391	424	451
Biological & agricultural	2,275	2,841	3,231	3,046	3,437	3,407	3,331	3,347	3,338	3,244	3,313	3,447	3,431	3,658	3,731	4,171	4,329
Math/computer sciences	1,766	1,766	1,632	1,848	2,488	2,765	3,048	3,528	3,797	3,841	3,996	4,151	4,247	4,121	4,327	4,222	4,365
Mathematics	1,428	1,300	1,057	877	980	954	1,011	1,116	1,301	1,377	1,370	1,476	1,486	1,446	1,532	1,493	1,579
Computer sciences	338	466	575	971	1,508	1,811	2,037	2,412	2,496	2,464	2,626	2,675	2,761	2,675	2,795	2,729	2,786
Social & behavioral sciences	8,528	10,307	10,823	11,557	12,189	11,948	12,356	12,515	12,529	12,564	13,667	14,262	15,435	16,046	17,257	18,968	20,731
Psychology	3,045	4,004	4,343	4,668	5,185	5,093	5,417	5,426	5,327	5,326	5,838	6,283	6,808	6,923	7,484	8,285	9,397
Social sciences	5,483	6,303	6,480	6,889	7,004	6,855	6,939	7,089	7,202	7,238	7,829	7,979	8,627	9,123	9,773	10,683	11,334
Engineering	372	698	937	1,329	1,755	2,100	2,244	2,400	2,770	2,808	3,082	3,269	3,357	3,669	4,094	4,423	4,632
Chemical engineering	27	69	120	176	176	208	285	240	243	215	229	192	173	231	224	279	306
Civil engineering	107	185	214	316	382	415	414	373	475	413	445	520	540	635	831	953	1045
Electrical engineering	58	134	143	221	335	438	495	639	717	813	916	991	934	1,045	1,051	1,149	1,204
Industrial engineering	56	75	128	166	206	278	227	279	319	324	358	341	436	472	555	536	512
Mechanical engineering	20	55	73	127	166	199	228	254	247	295	326	354	360	371	400	417	450
Other engineering	104	180	259	323	490	562	595	615	769	748	808	871	914	915	1,033	1,089	1,115
Engineering technology	90	116	125	152	103	114	142	215	205	242	243	306	300	307	383	383	441

SOURCES: National Center for Education Statistics, Earned Degrees and Completion Surveys (Washington, DC: 1995), unpublished tabulations; and National Science Foundation, Science Resources Studies Division, unpublished tabulations.

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Appendix table 2-28.

Earned master's degrees, by field, race/ethnicity, and citizenship: 1977-95

Field and race/ethnicity	1977	1979	1981	1985	1987	1989	1991	1993	1994	1995
Total										
All degrees	318,241	302,075	296,798	287,213	290,532	311,050	338,498	370,973	389,008	399,428
Science and engineering	63,779	59,684	59,598	64,726	66,774	70,333	72,828	81,415	86,080	88,431
Natural sciences[a]	16,234	16,350	15,332	14,045	13,461	13,260	12,713	13,462	14,340	14,770
Math and computer sciences	6,496	6,101	6,787	9,989	11,808	12,829	12,956	14,251	14,529	14,522
Social sciences[b]	24,798	21,723	20,763	19,757	19,448	20,509	23,152	26,044	28,504	30,522
Engineering	16,251	15,510	16,716	20,935	22,057	23,735	24,007	27,658	28,707	28,617
Engineering technology	NA	NA	NA	816	883	1,135	1,188	1,555	1,547	1,577
U.S. citizens and permanent residents										
All degrees	300,334	281,811	273,184	254,401	246,939	263,166	285,260	310,449	324,203	331,744
Science and engineering	55,963	50,846	49,340	50,751	50,330	51,491	52,849	57,720	61,769	63,323
Natural sciences[a]	14,437	14,410	13,411	11,676	10,721	10,352	9,408	9,809	10,384	10,871
Math and computer sciences	5,760	5,099	5,342	7,385	8,179	8,370	8,527	8,789	8,868	8,823
Social sciences[b]	23,071	19,920	18,785	17,230	15,990	17,089	19,365	21,747	24,237	25,817
Engineering	12,695	11,417	11,802	14,460	15,440	15,680	15,549	17,375	18,280	17,812
Engineering technology	NA	NA	NA	596	712	909	959	1,175	1,256	1,268
White, all degrees	266,109	249,401	241,255	223,649	216,807	230,322	247,524	265,668	273,913	277,437
Science and engineering	50,420	45,748	43,967	43,982	43,360	43,945	44,513	47,975	50,711	51,417
Natural sciences[a]	13,405	13,282	12,411	10,559	9,623	9,262	8,300	8,504	8,859	9,242
Math and computer sciences	5,256	4,625	4,708	6,176	6,729	6,818	6,705	6,818	6,665	6,547
Social sciences[b]	20,315	17,759	16,701	15,061	14,171	15,033	16,873	18,733	20,718	21,807
Engineering	11,444	10,082	10,147	12,186	12,837	12,832	12,635	13,920	14,469	13,821
Engineering technology	NA	NA	NA	526	581	802	830	1,041	994	982
Asian, all degrees	5,145	5,519	6,304	7,805	8,129	10,174	11,070	13,169	14,559	15,906
Science and engineering	1,749	1,929	2,170	3,285	3,455	4,100	4,310	4,846	5,422	5,683
Natural sciences[a]	388	469	365	450	464	545	532	615	698	802
Math and computer sciences	198	253	376	779	962	1,072	1,203	1,303	1,461	1,478
Social sciences[b]	426	357	350	505	379	491	567	668	820	831
Engineering	737	850	1,079	1,551	1,650	1,992	2,008	2,260	2,443	2,572
Engineering technology	NA	NA	NA	25	46	40	60	40	46	55
Black, all degrees	21,041	19,422	17,152	13,960	13,173	13,455	15,857	18,897	20,936	22,954
Science and engineering	2,321	2,003	1,801	1,742	1,784	1,652	2,090	2,554	2,849	3,339
Natural sciences[a]	351	382	351	290	301	238	261	310	347	383
Math and computer sciences	200	136	137	233	280	257	383	406	474	498
Social sciences[b]	1,530	1,239	1,053	889	800	802	1,048	1,274	1,439	1,793
Engineering	240	246	260	330	403	355	398	564	589	665
Engineering technology	NA	NA	NA	37	42	55	47	61	72	85

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Appendix table 2-28.

Earned master's degrees, by field, race/ethnicity, and citizenship: 1977-95

Field and race/ethnicity	1977	1979	1981	1985	1987	1989	1991	1993	1994	1995
Hispanic, all degrees	7,071	6,470	7,439	7,730	7,781	8,133	9,684	11,371	13,177	13,905
Science and engineering	1,325	1,001	1,237	1,514	1,584	1,585	1,736	2,092	2,514	2,585
Natural sciences[a]	245	227	251	332	310	266	281	334	436	392
Math and computer sciences	91	61	102	149	183	178	213	240	244	273
Social sciences[b]	738	498	599	687	579	673	774	937	1115	1209
Engineering	251	215	285	346	512	468	468	581	719	711
Engineering technology	NA	NA	NA	6	17	10	19	25	37	40
Native American, all degrees	968	999	1,034	1,257	1,049	1,082	1,125	1,344	1,618	1,542
Science and engineering	148	165	165	228	147	209	200	253	273	299
Natural sciences[a]	48	50	33	45	23	41	34	46	44	52
Math and computer sciences	15	24	19	48	25	45	23	22	24	27
Social sciences[b]	62	67	82	88	61	90	103	135	145	177
Engineering	23	24	31	47	38	33	40	50	60	43
Engineering technology	NA	NA	NA	2	26	2	3	8	3	6
Foreign citizens										
All degrees	17,345	19,427	22,058	26,952	28,264	32,123	37,611	44,109	46,506	48,756
Science and engineering	7,805	8,544	9,749	12,506	13,045	15,143	17,049	20,150	20,879	21,321
Natural sciences[a]	1,797	1,895	1,864	2,178	2,132	2,504	2,856	3,145	3,411	3,299
Math and computer sciences	736	937	1,368	2,394	2,903	3,418	3,878	4,917	5,007	5,036
Social sciences[b]	1,727	1,752	1,954	2,240	2,229	2,474	2,795	2,969	3,104	3,290
Engineering	3,545	3,960	4,563	5,694	5,781	6,747	7,520	9,119	9,357	9,696
Engineering technology	NA	NA	NA	124	127	131	172	279	291	309

N/A = not available

NOTES: Data by racial/ethnic group were collected on a biennial schedule until 1990 and annually thereafter. Data by racial/ethnic group are collected by broad fields of study only; therefore, these data cannot be adjusted to the exact field taxonomies used by the National Science Foundation.

[a] Natural sciences here include physical, earth, atmospheric, oceanographic, biological, and agricultural sciences.

[b] Social sciences include psychology, sociology, and other social sciences.

SOURCE: National Science Foundation, Science Resources Studies Division, *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1977-94*, NSF 96-329 (Arlington, VA: 1996).

See text table 2-8.

Appendix table 2-29.
Graduate enrollment in engineering, by citizenship: 1985-96

Citizenship	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Total enrollment	95,505	107,196	110,778	112,007	114,048	117,834	123,497	128,854	128,081	122,242	118,506	113,063
U.S. citizens & permanent residents	69,930	77,895	78,609	76,579	77,133	78,687	81,948	84,831	85,435	82,325	80,153	74,403
Foreign students	25,575	29,301	32,169	35,428	36,915	39,147	41,549	44,023	42,646	39,917	38,353	38,660

NOTES: Data include full-time and part-time students. The schools surveyed by the Engineering Workforce Commission for engineering enrollments are slightly different from those surveyed by the National Science Foundation for graduate enrollments in all fields of science and engineering; therefore, numbers of students reported are slightly different.

SOURCE: American Association of Engineering Societies, Engineering Workforce Commission, *Engineering and Technology Enrollments, Fall 1979-1996* (Washington, DC: 1997), unpublished tabulations.

See figure 2-15.

Science & Engineering Indicators – 1998

Appendix table 2-30.

Earned doctoral degrees, by field and sex: 1975-95

Field	1975	1977	1979	1981	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Total doctoral degree recipients																	
All degrees	32,952	31,716	31,239	31,356	31,281	31,337	31,297	31,902	32,370	33,501	34,326	36,067	37,522	38,856	39,771	41,017	41,610
Science and engineering	18,799	18,008	17,872	18,257	18,635	18,748	18,935	19,437	19,894	20,933	21,731	22,867	24,019	24,673	25,441	26,202	26,515
Natural sciences	8,103	7,676	7,817	7,995	8,194	8,336	8,436	8,483	8,655	9,172	9,185	9,763	10,159	10,435	10,529	11,079	11,024
Physical	3,076	2,721	2,674	2,627	2,814	2,851	2,934	3,120	3,238	3,350	3,261	3,524	3,625	3,780	3,699	3,977	3,840
Earth/atm/ocean	625	689	642	583	624	608	599	559	602	695	723	738	815	794	771	824	778
Biological & agricultural	4,402	4,266	4,501	4,785	4,756	4,877	4,903	4,804	4,815	5,127	5,201	5,501	5,719	5,861	6,059	6,278	6,406
Math/computer sciences	1,147	964	979	960	987	993	998	1,128	1,190	1,264	1,471	1,597	1,839	1,927	2,026	2,021	2,188
Mathematics	1,147	933	769	728	701	698	688	729	740	749	859	892	1,039	1,058	1,146	1,118	1,190
Computer sciences	0	31	210	232	286	295	310	399	450	515	612	705	800	869	880	903	998
Social & behavioral sciences	6,538	6,720	6,582	6,774	6,673	6,506	6,335	6,450	6,337	6,310	6,532	6,613	6,806	6,873	7,188	7,280	7,296
Psychology	2,751	2,990	3,091	3,358	3,347	3,257	3,118	3,126	3,173	3,074	3,208	3,281	3,250	3,263	3,419	3,380	3,419
Social sciences	3,787	3,730	3,491	3,416	3,326	3,249	3,217	3,324	3,164	3,236	3,324	3,332	3,556	3,610	3,769	3,900	3,877
Engineering	3,011	2,648	2,494	2,528	2,781	2,913	3,166	3,376	3,712	4,187	4,543	4,894	5,215	5,438	5,696	5,822	6,007
Chemical engineering	396	329	315	317	392	409	504	531	584	685	712	658	691	725	737	725	708
Civil engineering	361	336	302	358	397	408	391	429	477	531	538	553	575	594	624	684	656
Electrical engineering	714	667	611	549	625	660	716	806	779	1,010	1,137	1,276	1,405	1,483	1,543	1,673	1,731
Mechanical engineering	487	372	366	360	379	427	513	536	657	715	760	884	875	987	1,030	1,015	1,024
Materials engineering	272	248	236	234	268	271	303	305	392	374	380	440	489	485	535	539	588
Other engineering	781	696	664	710	720	738	739	769	823	872	1,016	1,083	1,180	1,164	1,229	1,186	1,300
Males																	
All degrees	25,751	23,858	22,302	21,464	20,748	20,638	20,553	20,595	20,938	21,682	21,813	22,962	23,652	24,436	24,658	25,211	25,277
Science and engineering	15,870	14,775	14,128	14,056	13,920	13,956	14,044	14,270	14,582	15,271	15,622	16,498	17,088	17,593	17,789	18,283	18,242
Natural sciences	6,960	6,530	6,436	6,409	6,360	6,483	6,452	6,426	6,484	6,779	6,649	7,101	7,320	7,413	7,311	7,713	7,534
Physical	2,812	2,477	2,382	2,318	2,441	2,452	2,467	2,610	2,710	2,783	2,642	2,863	2,946	3,010	2,919	3,149	2,962
Earth/atm/ocean	595	630	584	527	529	502	491	464	490	560	575	597	636	606	611	641	608
Biological & agricultural	3,553	3,423	3,470	3,564	3,390	3,529	3,494	3,352	3,284	3,436	3,432	3,641	3,738	3,797	3,781	3,923	3,964
Math/computer sciences	1,038	837	833	822	838	841	859	959	1,000	1,087	1,208	1,329	1,523	1,602	1,624	1,648	1,737
Mathematics	1,038	811	650	616	588	583	582	608	615	628	704	734	840	853	882	882	925
Computer sciences	0	26	183	206	250	258	277	351	385	459	504	595	683	749	742	766	812
Social & behavioral sciences	4,913	4,834	4,427	4,396	4,065	3,870	3,765	3,734	3,628	3,504	3,597	3,589	3,497	3,646	3,678	3,735	3,658
Psychology	1,878	1,902	1,831	1,885	1,750	1,626	1,577	1,527	1,475	1,393	1,408	1,368	1,254	1,335	1,331	1,278	1,247
Social sciences	3,035	2,932	2,596	2,511	2,315	2,244	2,188	2,207	2,153	2,111	2,189	2,221	2,243	2,311	2,347	2,457	2,411
Engineering	2,959	2,574	2,432	2,429	2,657	2,762	2,968	3,151	3,470	3,901	4,168	4,479	4,748	4,932	5,176	5,187	5,313
Chemical engineering	391	319	306	306	369	382	463	470	524	620	632	580	608	612	643	612	599
Civil engineering	356	328	298	348	384	383	371	408	459	501	484	504	534	544	570	604	580
Electrical engineering	698	646	600	527	612	645	681	768	747	962	1,070	1,192	1,326	1,368	1,418	1,526	1,558
Mechanical engineering	483	366	361	354	371	412	487	518	640	686	731	846	818	942	973	946	961
Materials engineering	267	238	228	217	238	245	271	281	347	341	335	391	412	424	457	456	494
Other engineering	764	677	639	677	683	695	695	706	753	791	916	966	1,050	1,042	1,115	1,043	1,121

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Appendix table 2-30.

Earned doctoral degrees, by field and sex: 1975-95

Field	1975	1977	1979	1981	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
							Females										
All degrees	7,201	7,858	8,937	9,892	10,533	10,699	10,744	11,307	11,432	11,819	12,513	13,105	13,870	14,420	15,113	15,806	16,333
Science and engineering	2,929	3,233	3,744	4,201	4,715	4,792	4,891	5,167	5,312	5,662	6,109	6,369	6,931	7,080	7,652	7,919	8,273
Natural sciences	1,143	1,146	1,381	1,586	1,834	1,853	1,984	2,057	2,171	2,393	2,536	2,662	2,839	3,022	3,218	3,366	3,490
Physical	264	244	292	309	373	399	467	510	528	567	619	661	679	770	780	828	878
Earth/atm/ocean	30	59	58	56	95	106	108	95	112	135	148	141	179	188	160	183	170
Biological & agricultural	849	843	1,031	1,221	1,366	1,348	1,409	1,452	1,531	1,691	1,769	1,860	1,981	2,064	2,278	2,355	2,442
Math/computer sciences	109	127	146	138	149	152	139	169	190	177	263	268	316	325	402	373	451
Mathematics	109	122	119	112	113	115	106	121	125	121	155	158	199	205	264	236	265
Computer sciences	0	5	27	26	36	37	33	48	65	56	108	110	117	120	138	137	186
Social & behavioral sciences	1,625	1,886	2,155	2,378	2,608	2,636	2,570	2,716	2,709	2,806	2,935	3,024	3,309	3,227	3,510	3,545	3,638
Psychology	873	1,088	1,260	1,473	1,597	1,631	1,541	1,599	1,698	1,681	1,800	1,913	1,996	1,928	2,088	2,102	2,172
Social sciences	752	798	895	905	1,011	1,005	1,029	1,117	1,011	1,125	1,135	1,111	1,313	1,299	1,422	1,443	1,466
Engineering	52	74	62	99	124	151	198	225	242	286	375	415	467	506	522	635	694
Chemical engineering	5	10	9	11	23	27	41	61	60	65	80	78	83	113	94	113	109
Civil engineering	5	8	4	10	13	25	20	21	18	30	54	49	41	50	54	80	76
Electrical engineering	16	21	11	22	13	15	35	38	32	48	67	84	79	115	125	147	173
Mechanical engineering	4	6	5	6	8	15	26	18	17	29	29	38	57	45	57	69	63
Materials engineering	5	10	8	17	30	26	32	24	45	33	45	49	77	61	78	83	94
Other engineering	17	19	25	33	37	43	44	63	70	81	100	117	130	122	114	143	179

SOURCE: National Science Foundation, Science Resources Studies Division, *Selected Data on Science and Engineering Doctorate Awards: 1995*, NSF 96-303 (Arlington, VA: 1996).

See figure 2-16.

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Appendix table 2-31.

Earned doctoral degrees by field, race/ethnicity, and citizenship: 1977-95

Field and race/ethnicity	1977	1979	1981	1983	1985	1987	1989	1991	1992	1993	1994	1995
Total[a]												
All degrees	31,716	31,239	31,356	31,281	31,297	32,370	34,326	37,522	38,856	39,771	41,017	41,610
Science and engineering	18,008	17,872	18,257	18,635	18,935	19,894	21,731	24,019	24,673	25,441	26,202	26,515
Natural sciences[b]	7,676	7,817	7,995	8,194	8,436	8,655	9,185	10,159	10,435	10,529	11,079	11,024
Math and computer sciences	964	979	960	987	998	1,190	1,471	1,839	1,927	2,026	2,021	2,188
Social sciences[c]	6,720	6,582	6,774	6,673	6,335	6,337	6,532	6,806	6,873	7,188	7,280	7,296
Engineering	2,648	2,494	2,528	2,781	3,166	3,712	4,543	5,215	5,438	5,698	5,822	6,007
U.S. citizens and permanent residents												
All degrees	27,487	26,784	26,341	25,634	24,694	24,562	25,026	27,418	27,956	28,675	30,877	31,910
Science and engineering	14,881	14,711	14,654	14,518	14,065	14,055	14,591	15,909	15,940	16,570	18,184	18,961
Natural sciences[b]	6,427	6,604	6,640	6,706	6,634	6,450	6,628	7,058	7,037	7,091	8,103	8,352
Math and computer sciences	769	778	713	664	631	671	824	969	996	1,099	1,200	1,388
Social sciences[c]	5,886	5,712	5,830	5,666	5,206	5,021	4,910	5,408	5,387	5,683	5,828	5,885
Engineering	1,799	1,617	1,471	1,482	1,594	1,913	2,229	2,474	2,520	2,697	3,053	3,336
White, all degrees	23,654	22,396	22,470	22,251	21,306	21,122	21,570	23,179	23,599	24,027	24,585	24,608
Science and engineering	12,875	12,314	12,573	12,671	12,169	12,052	12,501	13,323	13,326	13,735	13,890	13,879
Natural sciences[b]	5,598	5,620	5,771	5,981	5,903	5,663	5,800	6,111	6,019	5,950	3,016	5,974
Math and computer sciences	671	658	610	569	527	548	688	774	803	886	880	988
Social sciences[c]	5,177	4,879	5,099	4,993	4,551	4,383	4,287	4,601	4,624	4,874	4,866	4,831
Engineering	1,429	1,157	1,093	1,128	1,188	1,458	1,726	1,837	1,880	2,025	2,020	2,086
Asian, all degrees	910	1,102	1,073	1,042	1,070	1,168	1,268	1,531	1,761	2,012	3,545	4,300
Science and engineering	745	884	827	780	809	925	986	1,180	1,344	1,610	2,989	3,666
Natural sciences[b]	342	377	344	359	346	369	403	474	559	686	1,481	1,857
Math and computer sciences	42	55	56	54	50	67	76	123	138	156	259	346
Social sciences[c]	112	146	142	120	132	162	146	178	196	241	382	432
Engineering	249	306	285	247	281	327	361	405	451	527	867	1,031
Black, all degrees	1,191	1,112	1,110	1,005	1,043	910	962	1,160	1,113	1,277	1,274	1,455
Science and engineering	342	347	346	338	374	319	366	459	407	468	496	557
Natural sciences[b]	85	84	89	84	100	95	105	111	106	135	149	168
Math and computer sciences	9	12	11	6	10	13	9	19	9	14	21	16
Social sciences[c]	233	231	227	219	230	186	219	274	243	269	272	302
Engineering	15	20	19	29	34	25	33	55	49	50	54	71
Hispanic, all degrees	489	547	529	608	634	708	694	867	909	973	1,029	1,055
Science and engineering	203	234	240	284	296	357	382	492	513	542	548	568
Natural sciences[b]	76	84	93	86	107	138	157	191	208	226	254	232
Math and computer sciences	12	12	5	7	18	15	15	21	20	23	20	21
Social sciences[c]	91	114	126	162	149	170	163	220	214	227	208	238
Engineering	24	24	16	29	22	34	47	60	71	66	66	77

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Appendix table 2-31.

Earned doctoral degrees by field, race/ethnicity, and citizenship: 1977-95

Field and race/ethnicity	1977	1979	1981	1983	1985	1987	1989	1991	1992	1993	1994	1995
Native American, all degrees	66	81	85	82	96	115	94	132	149	120	142	148
Science and engineering	31	29	28	30	41	53	53	56	69	43	64	69
Natural sciences[b]	14	6	8	13	21	20	25	27	26	17	24	26
Math and computer sciences	1	1	1	1	0	3	2	1	4	2	3	2
Social sciences[c]	15	19	15	15	19	23	19	22	28	22	31	31
Engineering	1	3	4	1	1	7	7	6	11	2	6	10
Temporary residents												
Total, all degrees	3,448	3,587	3,940	4,498	5,227	5,612	6,648	9,312	9,953	9,934	9,406	8,806
Science and engineering	2,675	2,689	2,983	3,412	4,047	4,468	5,391	7,642	8,092	8,113	7,521	6,992
Natural sciences[c]	1,079	1,046	1,140	1,273	1,517	1,704	1,975	2,936	3,213	3,191	2,815	2,502
Math and computer sciences	170	181	226	281	327	445	524	846	876	865	791	747
Social sciences[c]	651	645	675	688	784	787	952	1,226	1,260	1,273	1,262	1,220
Engineering	775	817	942	1,170	1,419	1,532	1,940	2,634	2,743	2,784	2,653	2,523
Citizenship unknown												
Total, all degrees	781	868	1,075	1,149	1,376	2,196	2,652	792	947	1,162	734	894
Science and engineering	452	472	620	705	823	1,371	1,749	468	641	758	497	562
Natural sciences[b]	170	167	215	215	285	501	582	165	185	247	161	170
Math and computer sciences	25	20	21	42	40	74	123	24	55	62	30	53
Social sciences[c]	183	225	269	319	345	529	670	172	226	232	190	191
Engineering	74	60	115	129	153	267	374	107	175	217	116	148

[a] Data include all doctorates awarded to U.S. citizens and permanent residents, temporary residents, and persons whose citizenship is unknown.

[b] Natural sciences here include physical, earth, atmospheric, oceanographic, biological, and agricultural sciences.

[c] Social sciences include psychology, sociology, and other social sciences.

SOURCE: National Science Foundation, Science Resources Studies Division, *Selected Data on Science and Engineering Doctorate Awards: 1995*, NSF 96-303 (Arlington, VA: 1996).

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Appendix table 2-32.
Earned doctoral degrees in science and engineering, by region/country: Most recent year

Region/country	All doctoral degrees	All S&E doctoral degrees	Degree field				
			Natural sciences[a]	Math & computer sciences	Agriculture	Social sciences[b]	Engineering
Total, three world regions	155,733	89,818	37,229	6,830	5,829	15,663	24,267
Asia							
Total	32,087	15,678	6,304	224	2,048	775	6,327
China	4,364	3,230	1,191	NA	182	198	1,659
India	9,369	4,425	3,505	NA	572	NA	348
Japan	13,044	5,453	1,135	NA	1,008	301	3,009
South Korea	4,462	1,920	358	169	223	232	938
Taiwan	848	650	115	55	63	44	373
Europe							
Total	78,791	45,647	20,120	4,386	2,576	7,030	11,535
European Union	60,364	33,488	16,769	2,856	1,764	4,736	7,363
Austria	1,634	851	268	98	123	105	257
Denmark	333	257	137	0	34	33	53
Finland	1,882	757	245	86	54	147	225
France	9,801	8,575	3,738	1,129	84	2,197	1,427
Germany	22,404	10,128	6,077	616	573	699	2,163
Greece	932	367	128	44	36	66	93
Ireland	344	252	156	21	13	11	51
Italy	3,603	1,432	640	NA	175	226	391
The Netherlands	2,405	1,308	516	NA	155	264	373
Spain	5,193	1,794	1,109	88	104	194	299
Sweden	2,072	1,255	399	172	62	148	474
United Kingdom	9,761	6,512	3,356	602	351	646	1,557
European Free Trade Associaton	4,304	2,009	814	135	172	347	541
Norway	500	169	7	5	42	8	107
Switzerland	3,804	1,840	807	130	130	339	434
Central Europe	14,123	10,150	2,537	1,395	640	1,947	3,631
Czech Republic	118	108	35	7	1	21	44
Russia	14,005	10,042	2,502	1,388	639	1,926	3,587
North America							
Total	44,855	28,493	10,805	2,220	1,205	7,858	6,405
Canada	3,356	2,027	689	183	117	490	548
Mexico	488	259	120	15	10	79	35
United States	41,011	26,207	9,996	2,022	1,078	7,289	5,822

N/A = not available

NOTES: Data are compiled from numerous national and international sources, and degree fields may not be strictly comparable. U.K. data are for 1996. Data for China, Japan, South Korea, Taiwan, Austria, Switzerland, and the United States are for 1995. Data for Finland, France, Germany, Italy, Sweden, Norway, Czech Republic, Russia, Canada, and Mexico are for 1994. Data for Denmark, Greece, Ireland, the Netherlands, and Spain are for 1993. Indian data are for 1991. Japanese data include "thesis" doctorates called Ronbun Hakase, earned by employees in industry.

[a] Natural sciences here include physical, earth, atmospheric, oceanographic, and biological sciences.

[b] Social sciences include psychology, sociology, and other social sciences.

SOURCES: **ASIA: China**—National Research Center for Science and Technology for Development, unpublished tabulations, and UNESCO, *Statistical Yearbook* (Paris: 1996); **India**—Department of Science and Technology, *Research and Development Statistics 1994–95* (New Delhi: 1996); **Japan**—Ministry of Education, Science, and Culture (Monbusho), *Monbusho Survey of Education* (Tokyo: annual series); **South Korea**—Ministry of Education, *Statistical Yearbook of Education* (Seoul: 1996); **Taiwan**—Ministry of Education, *Educational Statistics of the Republic of China* (Taipei: 1996); **EUROPEAN UNION: Austria**—Austrian Central Statistical Office, unpublished tabulations; **Denmark**—Department of Higher Education, Ministry of Education, unpublished tabulations (1997); **Finland**—Central Statistical Office, unpublished tabulations (1997), and OECD/CERI; **France**—Ministère de l'Éducation Nationale, *Repères et Références Statistiques sur les Enseignements et la Formation* (Vanves, France: 1996); **Germany**—Statistisches Bundesamt, *Prüfungen an Hochschulen* (Wiesbaden); **Greece**—National Statistical Service of Greece, unpublished tabulations (1997), and OECD/CERI; **Ireland**—OECD/CERI; **Italy**—Consiglio nazionale delle ricerche, unpublished tabulations (1997); **the Netherlands**—Department for Statistics of Education and Science, Netherlands Central Bureau of Statistics, unpublished tabulations (1997); **Spain**—Estadisticas e Investigaciones Sociales, Instituto National de Estadistica, unpublished tabulations (1997) and OECD/CERI; **Sweden**—Statistics Sweden, unpublished tabulations (1997), and OECD/CERI; **United Kingdom**—Higher Education Statistical Agency, *Students in Higher Education Institutions, 1995/96* (Cheltenham: 1997); **EUROPEAN FREE TRADE ASSOCIATION: Norway**—Institute for Studies in Research and Higher Education, the Norwegian Research Council, unpublished tabulations (1997); **Switzerland**—Swiss Federal Statistical Office, unpublished tabulations (1997); **CENTRAL AND EASTERN EUROPE: Czech Republic**—UNESCO (1996); **Russia**—UNESCO (1996); **NORTH AMERICA: Canada**—UNESCO (1996) and OECD/CERI; **Mexico**—Asociación Nacional de Universidades e Instituciones de Educación Superior, *Anuario Estadistico 1995: Posgrado* (Mexico: 1996); and **United States**—National Science Foundation, Science Resources Studies Division, *Science and Engineering Degrees 1966-94*, NSF 96-321 (Arlington, VA: 1996).

Science & Engineering Indicators – 1998

Appendix table 2-33.

Proportion of NS&E doctoral degrees earned by foreign students in selected countries: 1995 or most current year

(Percentages)

Country	Foreign doctoral recipients	
	Natural sciences	Engineering
United States	40.5	57.9
United Kingdom	28.5	49.1
France	29.1	34.2
Germany	7.9	15.8
Japan	22.1	32.2

NOTE: Data for Germany and Japan are for 1994.

NS&E = natural sciences and engineering

SOURCES: **France**—Ministère de l'Éducation Nationale, *Repères et Références Statistiques sur les Enseignements et la Formation* (Vanves, France: 1996); **Germany**—Statistiches Bundesamt, *Prüfungen an Hochschulen* (Wiesbaden); **Japan**—Ministry of Education, Science, and Culture (Monbusho), *Monbusho Survey of Education* (Tokyo: Annual Series); **United Kingdom**—Higher Education Statistical Agency, unpublished tabulations; **United States**—National Science Foundation, Science Resources Studies Division, *Selected Data on Science and Engineering Doctorate Awards, 1995*, NSF 96-303 (Arlington, VA: 1996).

See figure 2-17. *Science & Engineering Indicators – 1998*

Appendix table 2-34.

Foreign students enrolled in U.S. universities from 12 major places of origin, by educational level and major field of study: 1995-96

				Percentage in S&E fields				Percentage in non-S&E fields	
Country	Total all fields	Educational level	Number of students surveyed[a]	Natural sciences	Math & computer sciences	Social sciences	Engineering	Business management	Other
Japan	45,531	Undergraduate	32,034	4.5	3.7	15.9	3.1	19.6	53.2
		Graduate	7,819	7.3	3.4	24.7	7.4	17.2	40.0
China	39,613	Undergraduate	4,851	6.8	14.8	4.1	10.4	27.6	36.3
		Graduate	32,512	32.6	13.1	5.9	24.9	8.9	14.6
South Korea	36,231	Undergraduate	16,333	5.8	7.1	6.3	8.0	21.7	51.1
		Graduate	15,045	15.1	7.0	11.2	18.7	12.1	35.9
Taiwan	32,702	Undergraduate	11,522	3.7	8.2	4.2	9.6	33.3	41.0
		Graduate	18,904	12.0	10.1	6.7	24.2	19.4	27.6
India	31,743	Undergraduate	6,049	7.9	14.9	5.8	21.5	25.0	24.9
		Graduate	25,593	13.2	17.1	4.2	41.3	11.7	12.5
Canada	23,005	Undergraduate	12,987	7.8	2.2	14.5	6.1	13.3	56.1
		Graduate	8,851	9.9	1.5	15.5	4.6	6.7	61.8
Malaysia	14,015	Undergraduate	11,630	3.2	6.8	3.8	33.8	33.7	18.7
		Graduate	1,956	8.6	11.0	11.6	20.1	24.2	24.5
Indonesia	12,820	Undergraduate	9,325	2.7	5.5	2.9	21.6	48.8	18.5
		Graduate	2,947	10.2	6.5	10.6	22.0	35.7	15.0
Thailand	12,165	Undergraduate	3,599	3.6	8.0	4.6	15.0	32.7	36.1
		Graduate	7,347	7.6	5.2	5.6	19.5	47.7	14.4
Hong Kong	12,018	Undergraduate	9,055	3.6	8.6	6.0	14.5	40.8	26.5
		Graduate	2,348	12.1	12.5	10.9	16.5	22.3	25.7
Germany	9,017	Undergraduate	3,662	7.6	4.2	10.8	5.1	24.1	48.2
		Graduate	4,304	18.1	7.7	13.0	12.3	17.9	31.0
Mexico	8,687	Undergraduate	5,079	5.0	4.4	6.9	14.4	26.1	43.2
		Graduate	3,070	21.4	7.1	14.7	19.3	14.8	22.7

NOTE: Data include foreign students in all levels of U.S. higher education.

[a] The numbers of foreign students surveyed by level and field of study do not equal the total numbers of foreign students in all fields from each country. Many universities were unable to respond to the detailed questions posed by the survey regarding the level and major field of study for their registered foreign students.

SOURCES: Institute of International Education (IIE), *Open Doors, 1995-96: Report on International Education Exchange* (New York: 1996); and IIE, *Profiles 1995-96, Detailed Analyses of the Foreign Student Population* (New York), unpublished tabulations.

Science & Engineering Indicators - 1998

Appendix table 2-35.

Earned doctoral degrees, by field and citizenship: 1986-95

Field	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Total[a]										
All degrees	31,902	32,370	33,501	34,326	36,067	37,522	38,856	39,771	41,017	41,610
Science and engineering	19,437	19,894	20,933	21,731	22,867	24,019	24,673	25,441	26,202	26,515
Natural sciences[b]	8,483	8,655	9,172	9,185	9,763	10,159	10,435	10,529	11,079	11,024
Math and computer sciences	1,128	1,190	1,264	1,471	1,597	1,839	1,927	2,026	2,021	2,188
Social sciences[c]	6,450	6,337	6,310	6,532	6,613	6,806	6,873	7,188	7,280	7,296
Engineering	3,376	3,712	4,187	4,543	4,894	5,215	5,438	5,698	5,822	6,007
U.S. citizens										
All degrees	23,086	22,984	23,291	23,400	24,905	25,561	25,977	26,420	27,129	27,603
Science and engineering	13,022	12,966	13,369	13,467	14,166	14,624	14,558	14,929	15,162	15,460
Natural sciences[b]	6,139	6,070	6,282	6,225	6,505	6,585	6,501	6,461	6,642	6,595
Math and computer sciences	568	588	626	731	723	851	876	921	930	1,038
Social sciences[c]	4,932	4,750	4,681	4,647	4,981	5,102	5,072	5,319	5,375	5,445
Engineering	1,383	1,558	1,780	1,864	1,957	2,086	2,109	2,228	2,215	2,382
Non-U.S. citizens										
All degrees	6,709	7,190	7,817	8,274	9,791	11,169	11,932	12,189	13,154	13,113
Science and engineering	5,154	5,557	6,066	6,515	7,768	8,927	9,474	9,754	10,543	10,493
Natural sciences[b]	1,896	2,084	2,333	2,378	2,974	3,409	3,749	3,821	4,276	4,259
Math and computer sciences	478	528	567	617	797	964	996	1,043	1,061	1,097
Social sciences[c]	1,065	1,058	1,079	1,215	1,331	1,532	1,575	1,637	1,715	1,660
Engineering	1,715	1,887	2,087	2,305	2,666	3,022	3,154	3,253	3,491	3,477
Non-U.S. citizens with permanent visas										
All degrees	1,433	1,578	1,622	1,626	1,698	1,857	1,979	2,255	3,748	4,307
Science and engineering	994	1,089	1,130	1,124	1,197	1,285	1,382	1,641	3,022	3,501
Natural sciences[b]	321	380	429	403	437	473	536	630	1,461	1,757
Math and computer sciences	83	83	86	93	102	118	120	178	270	350
Social sciences[c]	247	271	249	263	269	306	315	364	453	440
Engineering	343	355	366	365	389	388	411	469	838	954
Non-U.S. citizens with temporary visas										
All degrees	5,276	5,612	6,195	6,648	8,093	9,312	9,953	9,934	9,406	8,806
Science and engineering	4,160	4,468	4,936	5,391	6,571	7,642	8,092	8,113	7,521	6,992
Natural sciences[b]	1,575	1,704	1,904	1,975	2,537	2,936	2,741	3,191	2,815	2,502
Math and computer sciences	395	445	481	524	695	846	876	865	791	747
Social sciences[c]	818	787	830	952	1,062	1,226	1,260	1,273	1,262	1,220
Engineering	1,372	1,532	1,721	1,940	2,277	2,634	2,743	2,784	2,653	2,523

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Appendix table 2-35.

Earned doctoral degrees, by field and citizenship: 1986-95

Field	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
					Citizenship unknown					
All degrees	2,107	2,196	2,393	2,652	1,371	792	947	1,162	734	894
Science and engineering	1,261	1,371	1,498	1,749	933	468	641	758	497	562
Natural sciences[b]	448	446	557	582	284	165	185	247	161	170
Math and computer sciences	82	74	71	123	77	24	55	62	30	53
Social sciences[c]	453	529	550	670	301	172	226	232	190	191
Engineering	278	267	320	374	271	107	175	217	116	148

[a] Data include all doctorates awarded to U.S. citizens and permanent residents, temporary residents, and persons whose citizenship is unknown.

[b] Natural sciences here include physical, earth, atmospheric, oceanographic, biological, and agricultural sciences.

[c] Social sciences include psychology, sociology, and other social sciences.

SOURCE: National Science Foundation, Science Resources Studies Division, *Selected Data on Science and Engineering Doctorate Awards: 1995*, NSF 96-303 (Arlington, VA: 1996).

See figure 2-17.

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Science & Engineering Indicators – 1998

Appendix table 2-36.

Total S&E doctoral degrees earned by Asian students from Asian and U.S. universities: 1975-95

	Asian universities	U.S. universities
1975	4,057	NA
1976	4,634	NA
1977	4,959	NA
1978	5,211	NA
1979	5,597	NA
1980	5,892	991
1981	6,149	1,031
1982	6,408	1,168
1983	6,652	1,339
1984	7,091	1,531
1985	7,848	1,761
1986	8,032	1,889
1987	8,422	2,218
1988	9,701	2,511
1989	10,144	2,872
1990	10,283	4,008
1991	11,053	4,911
1992	11,767	5,406
1993	12,235	5,628
1994	13,812	6,229
1995	15,678	6,352

NA = not available

NOTE: Asian countries comprise China, India, Japan, South Korea, and Taiwan. Asian students in U.S. universities include those on either temporary or permanent visas.

SOURCES: **China**—National Center for Science and Technology for Development, unpublished tabulations, 1997; **India**—Department of Science and Technology, *Research and Development Statistics 1994-95* (New Delhi: 1996); **Japan**—Ministry of Education, Science, and Culture (Monbusho), *Monbusho Survey of Education* (Tokyo: annual series); **South Korea**—Ministry of Education, *Statistical Yearbook of Education, 1996* (Seoul: 1996); **Taiwan**—Ministry of Education, *Educational Statistics of the Republic of China* (Taipei: 1996); **United States**—National Science Foundation, Science Resources Studies Division (NSF/SRS), *Selected Data on Science and Engineering Doctorate Awards: 1995*, NSF 96-303 (Arlington, VA: 1996); and NSF/SRS, *Science and Engineering Doctorates: 1960-84* (Washington, DC: n.d.).

See figure 2-18. *Science & Engineering Indicators – 1998*

Appendix table 2-37.

Foreign doctoral recipients from U.S. universities who plan to stay in the United States, by field and region/country of origin: 1990-96

Region /country of origin	1990					1991					1992					1993				
	Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.	
		No.	%	No.	%		No.	%	No.	%		No.	%	No.	%		No.	%	No.	%
	All fields																			
Asia	5,224	2,390	45.8	1,727	33.1	6,252	3,596	57.5	2,268	36.3	6,938	4,375	63.1	2,525	36.4	7,136	4,397	61.6	2,367	33.2
China	1,225	725	59.2	502	41.0	1,919	1,523	79.4	920	47.9	2,238	1,980	88.5	1,080	48.3	2,416	2,134	88.3	1,077	44.6
Taiwan	1,149	477	41.5	314	27.3	1,321	635	48.1	367	27.8	1,431	702	49.1	364	25.4	1,456	584	40.1	304	20.9
Japan	186	73	39.2	55	29.6	164	66	40.2	45	27.4	172	74	43.0	46	26.7	182	66	36.3	43	23.6
South Korea	1,259	367	29.2	272	21.6	1,396	454	32.5	285	20.4	1,474	464	31.5	272	18.5	1,409	462	32.8	236	16.7
India	881	586	66.5	470	53.3	924	689	74.6	518	56.1	1,072	880	82.1	609	56.8	1,139	920	80.8	577	50.7
Other	524	162	30.9	114	21.8	528	229	43.4	133	25.2	551	275	49.9	154	27.9	534	231	43.3	130	24.3
Europe	1,097	540	49.2	411	37.5	1,329	740	55.7	534	40.2	1,332	809	60.7	544	40.8	1,461	842	57.6	552	37.8
Greece	137	67	48.9	50	36.5	185	96	51.9	66	35.7	168	94	56.0	58	34.5	199	116	58.3	78	39.2
United Kingdom	172	119	69.2	90	52.3	207	142	68.6	101	48.8	216	161	74.5	117	54.2	230	169	73.5	120	52.2
Germany	169	85	50.3	65	38.5	181	109	60.2	80	44.2	189	116	61.4	72	38.1	250	148	59.2	91	36.4
Italy	88	35	39.8	24	27.3	115	56	48.7	44	38.3	99	51	51.5	29	29.3	101	43	42.6	31	30.7
France	94	41	43.6	30	31.9	107	55	51.4	40	37.4	116	63	54.3	42	36.2	136	62	45.6	40	29.4
Spain	73	27	37.0	24	32.9	103	52	50.5	39	37.9	91	57	62.6	41	45.1	100	54	54.0	34	34.0
Other	364	166	45.6	128	35.2	431	230	53.4	164	38.1	453	267	58.9	185	40.8	445	250	56.2	158	35.5
N./S. America	1,099	434	39.5	329	29.9	1,293	599	46.3	434	33.6	1,302	615	47.2	393	30.2	1,279	589	46.1	382	29.9
Canada	419	191	45.6	153	36.5	511	241	47.2	187	36.6	509	260	51.1	191	37.5	486	239	49.2	176	36.2
Mexico	130	47	36.2	32	24.6	156	71	45.5	51	32.7	149	49	32.9	27	18.1	162	66	40.7	35	21.6
Argentina	78	32	41.0	24	30.8	73	46	63.0	33	45.2	101	47	46.5	28	27.7	68	37	54.4	25	36.8
Brazil	129	22	17.1	18	14.0	149	49	32.9	33	22.1	163	46	28.2	22	13.5	181	44	24.3	26	14.4
Chile	56	23	41.1	15	26.8	70	25	35.7	20	28.6	65	35	53.8	25	38.5	64	30	46.9	17	26.6
Colombia	46	24	52.2	18	39.1	64	33	51.6	19	29.7	54	29	53.7	14	25.9	47	21	44.7	17	36.2
Peru	28	14	50.0	12	42.9	40	27	67.5	16	40.0	42	27	64.3	19	45.2	48	27	56.3	17	35.4
Other	213	81	38.0	57	26.8	230	107	46.5	75	32.6	219	122	55.7	67	30.6	223	125	56.1	69	30.9

Appendix table 2-37.

Foreign doctoral recipients from U.S. universities who plan to stay in the United States, by field and region/country of origin: 1990-96

Region/country of origin	1994					1995					1996				
	Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.	
		No.	%	No.	%		No.	%	No.	%		No.	%	No.	%
									All fields						
Asia	7,903	5,100	64.5	2,654	33.6	8,014	5,407	67.5	2,827	35.3	8,179	5,593	68.4	3,491	42.7
China	2,772	2,548	91.9	1,223	44.1	2,979	2,744	92.1	1,341	45.0	3,201	2,896	90.5	1,788	55.9
Taiwan	1,576	654	41.5	322	20.4	1,485	669	45.1	293	19.7	1,404	653	46.5	344	24.5
Japan	235	95	40.4	57	24.3	233	102	43.8	69	29.6	245	104	42.4	67	27.3
South Korea	1,475	522	35.4	267	18.1	1,306	466	35.7	244	18.7	1,260	441	35.0	270	21.4
India	1,289	1,049	81.4	662	51.4	1,425	1,179	82.7	746	52.4	1,500	1,264	84.3	882	58.8
Other	556	232	41.7	123	22.1	586	247	42.2	134	22.9	569	235	41.3	140	24.6
Europe	1,506	902	59.9	597	39.6	1,644	1,033	62.8	656	39.9	1,611	1,038	64.4	711	44.1
Greece	188	85	45.2	60	31.9	197	111	56.3	60	30.5	152	85	55.9	57	37.5
United Kingdom	219	156	71.2	97	44.3	222	167	75.2	116	52.3	206	154	74.8	107	51.9
Germany	257	167	65.0	113	44.0	306	194	63.4	120	39.2	246	150	61.0	102	41.5
Italy	108	57	52.8	30	27.8	116	60	51.7	33	28.4	102	48	47.1	31	30.4
France	132	77	58.3	45	34.1	117	65	55.6	36	30.8	102	58	56.9	38	37.3
Spain	113	59	52.2	43	38.1	102	64	62.7	50	49.0	120	84	70.0	58	48.3
Other	489	301	61.6	209	42.7	584	372	63.7	241	41.3	683	459	67.2	318	46.6
N./S. America	1,368	641	46.9	405	29.6	1,326	620	46.8	384	29.0	1,426	672	47.1	450	31.6
Canada	490	239	48.8	174	35.5	524	278	53.1	171	32.6	505	269	53.3	190	37.6
Mexico	178	67	37.6	37	20.8	162	57	35.2	34	21.0	180	72	40.0	41	22.8
Argentina	68	45	66.2	33	48.5	77	38	49.4	26	33.8	91	60	65.9	39	42.9
Brazil	202	60	29.7	33	16.3	175	48	27.4	32	18.3	262	66	25.2	46	17.6
Chile	54	19	35.2	14	25.9	50	20	40.0	11	22.0	42	14	33.3	10	23.8
Colombia	59	35	59.3	14	23.7	56	24	42.9	15	26.8	54	27	50.0	18	33.3
Peru	42	30	71.4	16	38.1	39	23	59.0	14	35.9	45	31	68.9	21	46.7
Other	275	146	53.1	84	30.5	243	132	54.3	81	33.3	247	133	53.8	85	34.4

Appendix table 2-37.

Foreign doctoral recipients from U.S. universities who plan to stay in the United States, by field and region/country of origin: 1990-96

Region /country of origin	1990					1991					1992					1993				
	Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.	
		No.	%	No.	%		No.	%	No.	%		No.	%	No.	%		No.	%	No.	%
										Science & engineering										
Asia	4,380	2,113	48.2	1,521	34.7	5,280	3,189	60.4	1,995	37.8	5,786	3,784	65.4	2,165	37.4	5,[illegible]96	3,879	64.7	2,078	34.7
China	1,150	687	59.7	478	41.6	1,792	1,428	79.7	861	48.0	2,044	1,808	88.5	990	48.4	2,227	1,975	88.7	1,008	45.3
Taiwan	1,012	451	44.6	299	29.5	1,123	581	51.7	340	30.3	1,240	640	51.6	329	26.5	1,213	530	43.7	282	23.2
Japan	147	60	40.8	48	32.7	125	50	40.0	35	28.0	132	51	38.6	28	21.2	132	43	32.6	27	20.5
South Korea	971	307	31.6	226	23.3	1,107	390	35.2	243	22.0	1,123	373	33.2	220	19.6	1,118	394	35.2	201	18.0
India	709	467	65.9	371	52.3	752	554	73.7	408	54.3	860	703	81.7	485	56.4	932	759	81.4	462	49.6
Other	391	141	36.1	99	25.3	381	186	48.8	108	28.3	387	209	54.0	113	29.2	374	178	47.6	98	26.2
Europe	802	383	47.8	288	35.9	971	524	54.0	385	39.6	947	547	57.8	376	39.7	1,083	593	54.8	404	37.3
Greece	125	65	52.0	48	38.4	168	90	53.6	62	36.9	149	82	55.0	49	32.9	174	101	58.0	68	39.1
United Kingdom	104	73	70.2	53	51.0	134	91	67.9	66	49.3	139	101	72.7	75	54.0	157	113	72.0	86	54.8
Germany	123	59	48.0	46	37.4	118	67	56.8	51	43.2	124	67	54.0	44	35.5	164	86	52.4	55	33.5
Italy	63	23	36.5	15	23.8	86	37	43.0	30	34.9	73	37	50.7	25	34.2	76	30	39.5	23	30.3
France	65	25	38.5	16	24.6	67	28	41.8	21	31.3	77	31	40.3	20	26.0	93	29	31.2	17	18.3
Spain	40	11	27.5	11	27.5	59	26	44.1	19	32.2	45	27	60.0	20	44.4	63	27	42.9	21	33.3
Other	282	127	45.0	99	35.1	339	185	54.6	136	40.1	340	202	59.4	143	42.1	356	207	58.1	134	37.6
N./S. America	786	312	39.7	236	30.0	909	438	48.2	328	36.1	909	435	47.9	277	30.5	900	415	46.1	282	31.3
Canada	252	121	48.0	99	39.3	296	162	54.7	127	42.9	304	171	56.3	132	43.4	285	164	57.5	131	46.0
Mexico	104	34	32.7	21	20.2	128	58	45.3	45	35.2	115	39	33.9	22	19.1	139	54	38.8	30	21.6
Argentina	65	28	43.1	22	33.8	62	39	62.9	29	46.8	86	39	45.3	22	25.6	53	26	49.1	17	32.1
Brazil	98	17	17.3	13	13.3	118	35	29.7	25	21.2	133	37	27.8	18	13.5	151	34	22.5	19	12.6
Chile	50	18	36.0	12	24.0	54	21	38.9	17	31.5	48	25	52.1	18	37.5	52	24	46.2	15	28.8
Colombia	40	21	52.5	16	40.0	49	24	49.0	13	26.5	37	20	54.1	9	24.3	35	11	31.4	10	28.6
Peru	22	10	45.5	8	36.4	35	23	65.7	15	42.9	31	22	71.0	15	48.4	34	21	61.8	12	35.3
Other	155	63	40.6	45	29.0	167	76	45.5	57	34.1	155	82	52.9	41	26.5	151	81	53.6	48	31.8

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Appendix table 2-37.
Foreign doctoral recipients from U.S. universities who plan to stay in the United States, by field and region/country of origin: 1990-96

Region/country of origin	1994					1995					1996				
	Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.	
		No.	%	No.	%		No.	%	No.	%		No.	%	No.	%
							Science & engineering								
Asia	6,594	4,500	68.2	2,352	35.7	6,763	4,812	71.2	2,514	37.2	6,941	5,002	72.1	3,153	45.4
China	2,529	2,343	92.6	1,141	45.1	2,752	2,545	92.5	1,245	45.2	2,952	2,689	91.1	1,684	57.0
Taiwan	1,297	593	45.7	296	22.8	1,240	615	49.6	275	22.2	1,153	596	51.7	320	27.8
Japan	182	79	43.4	51	28.0	155	63	40.6	48	31.0	165	71	43.0	44	26.7
South Korea	1,143	436	38.1	230	20.1	1,000	388	38.8	210	21.0	977	368	37.7	237	24.3
India	1,065	871	81.8	536	50.3	1,206	1,003	83.2	632	52.4	1,276	1,084	85.0	753	59.0
Other	378	178	47.1	98	25.9	410	198	48.3	104	25.4	418	194	46.4	115	27.5
Europe	1,098	638	58.1	446	40.6	1,199	740	61.7	487	40.6	1,173	735	62.7	513	43.7
Greece	166	75	45.2	54	32.5	174	98	56.3	57	32.8	133	76	57.1	51	38.3
United Kingdom	131	90	68.7	59	45.0	134	102	76.1	77	57.5	119	86	72.3	61	51.3
Germany	196	124	63.3	93	47.4	208	124	59.6	83	39.9	171	103	60.2	75	43.9
Italy	83	42	50.6	21	25.3	81	37	45.7	22	27.2	77	34	44.2	22	28.6
France	96	51	53.1	30	31.3	83	38	45.8	23	27.7	69	31	44.9	22	31.9
Spain	58	23	39.7	20	34.5	51	29	56.9	24	47.1	66	41	62.1	28	42.4
Other	368	233	63.3	169	45.9	468	312	66.7	201	42.9	538	364	67.7	254	47.2
N./S. America	955	462	48.4	302	31.6	862	417	48.4	276	32.0	989	484	48.9	322	32.6
Canada	275	160	58.2	123	44.7	273	173	63.4	119	43.6	277	182	65.7	130	46.9
Mexico	142	49	34.5	29	20.4	128	45	35.2	26	20.3	158	59	37.3	32	20.3
Argentina	56	37	66.1	28	50.0	49	22	44.9	17	34.7	67	43	64.2	27	40.3
Brazil	157	45	28.7	26	16.6	137	39	28.5	28	20.4	207	53	25.6	37	17.9
Chile	42	14	33.3	11	26.2	38	14	36.8	7	18.4	36	12	33.3	8	22.2
Colombia	48	28	58.3	9	18.8	45	15	33.3	10	22.2	42	20	47.6	13	31.0
Peru	32	20	62.5	12	37.5	26	16	61.5	10	38.5	30	21	70.0	14	46.7
Other	203	109	53.7	64	31.5	166	93	56.0	59	35.5	172	94	54.7	61	35.5

Appendix table 2-37.

Foreign doctoral recipients from U.S. universities who plan to stay in the United States, by field and region/country of origin: 1990-96

Region /country of origin	1990					1991					1992					1993				
	Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.	
		No.	%	No.	%		No.	%	No.	%		No.	%	No.	%		No.	%	No.	%
									Natural sciences											
Asia	2,200	1,172	53.3	890	40.5	2,610	1,776	68.0	1,186	45.4	2,958	2,198	74.3	1,362	46.0	3,025	2,225	73.6	1,303	43.1
China	763	474	62.1	357	46.8	1,229	997	81.1	652	53.1	1,423	1,271	89.3	763	53.6	1,508	1,348	89.4	751	49.8
Taiwan	458	221	48.3	153	33.4	421	247	58.7	152	36.1	504	291	57.7	175	34.7	514	270	52.5	164	31.9
Japan	58	31	53.4	25	43.1	46	25	54.3	17	37.0	50	26	52.0	17	34.0	48	17	35.4	15	31.3
South Korea	407	168	41.3	134	32.9	422	187	44.3	132	31.3	418	192	45.9	127	30.4	402	195	48.5	125	31.1
India	319	220	69.0	180	56.4	304	225	74.0	174	57.2	365	307	84.1	220	60.3	382	315	82.5	200	52.4
Other	195	58	29.7	41	21.0	188	95	50.5	59	31.4	198	111	56.1	60	30.3	171	80	46.8	48	28.1
Europe	422	203	48.1	159	37.7	542	301	55.5	227	41.9	507	291	57.4	206	40.6	599	332	55.4	232	38.7
Greece	50	27	54.0	22	44.0	69	42	60.9	32	46.4	66	36	54.5	24	36.4	77	46	59.7	30	39.0
United Kingdom	54	40	74.1	31	57.4	75	54	72.0	45	60.0	70	48	68.6	37	52.9	95	69	72.6	55	57.9
Germany	76	35	46.1	25	32.9	82	45	54.9	37	45.1	78	42	53.8	30	38.5	100	49	49.0	32	32.0
Italy	34	11	32.4	9	26.5	45	23	51.1	17	37.8	43	19	44.2	13	30.2	44	16	36.4	13	29.5
France	27	9	33.3	5	18.5	37	16	43.2	9	24.3	40	16	40.0	11	27.5	49	15	30.6	11	22.4
Spain	18	4	22.2	4	22.2	37	15	40.5	9	24.3	16	12	75.0	8	50.0	30	20	66.7	15	50.0
Other	163	77	47.2	63	38.7	197	106	53.8	78	39.6	194	118	60.8	83	42.8	204	117	57.4	76	37.3
N./S. America	419	157	37.5	118	28.2	514	245	47.7	189	36.8	503	232	46.1	153	30.4	470	225	47.9	165	35.1
Canada	130	61	46.9	49	37.7	154	93	60.4	76	49.4	163	91	55.8	72	44.2	140	87	62.1	73	52.1
Mexico	65	19	29.2	12	18.5	80	35	43.8	26	32.5	69	25	36.2	16	23.2	84	31	36.9	19	22.6
Argentina	42	17	40.5	13	31.0	34	21	61.8	18	52.9	45	18	40.0	12	26.7	31	16	51.6	13	41.9
Brazil	44	10	22.7	8	18.2	66	14	21.2	11	16.7	79	19	24.1	9	11.4	75	16	21.3	10	13.3
Chile	22	9	40.9	6	27.3	33	16	48.5	12	36.4	24	18	75.0	13	54.2	34	17	50.0	12	35.3
Colombia	27	12	44.4	10	37.0	26	10	38.5	6	23.1	22	10	45.5	3	13.6	21	6	28.6	5	23.8
Peru	11	4	36.4	4	36.4	18	9	50.0	6	33.3	12	8	66.7	6	50.0	12	8	66.7	7	58.3
Other	78	25	32.1	16	20.5	103	47	45.6	34	33.0	89	43	48.3	22	24.7	73	44	60.3	26	35.6

Appendix table 2-37.

Foreign doctoral recipients from U.S. universities who plan to stay in the United States, by field and region/country of origin: 1990-96

Region/country of origin	1994					1995					1996				
	Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.	
		No.	%	No.	%		No.	%	No.	%		No.	%	No.	%
								Natural sciences							
Asia	3,359	2,571	76.5	1,473	43.9	3,447	2,715	78.8	1,525	44.2	3,604	2,843	78.9	1,852	51.4
China	1,665	1,554	93.3	834	50.1	1,802	1,671	92.7	883	49.0	1,960	1,810	92.3	1,162	59.3
Taiwan	509	266	52.3	154	30.3	502	290	57.8	140	27.9	462	259	56.1	155	33.5
Japan	59	34	57.6	23	39.0	51	25	49.0	19	37.3	54	28	51.9	21	38.9
South Korea	473	242	51.2	152	32.1	414	220	53.1	147	35.5	430	208	48.4	146	34.0
India	474	389	82.1	251	53.0	499	417	83.6	281	56.3	520	454	87.3	316	60.8
Other	179	86	48.0	59	33.0	179	92	51.4	55	30.7	178	84	47.2	52	29.2
Europe	631	371	58.8	275	43.6	675	405	60.0	282	41.8	697	460	66.0	327	46.9
Greece	84	36	42.9	26	31.0	87	43	49.4	30	34.5	64	34	53.1	20	31.3
United Kingdom	74	51	68.9	37	50.0	68	51	75.0	39	57.4	59	44	74.6	32	54.2
Germany	115	69	60.0	53	46.1	129	72	55.8	51	39.5	114	70	61.4	52	45.6
Italy	41	18	43.9	9	22.0	49	20	40.8	13	26.5	39	21	53.8	15	38.5
France	53	28	52.8	19	35.8	47	21	44.7	16	34.0	32	12	37.5	8	25.0
Spain	35	15	42.9	13	37.1	33	19	57.6	16	48.5	37	25	67.6	19	51.4
Other	229	154	67.2	118	51.5	262	179	68.3	117	44.7	352	254	72.2	181	51.4
N./S. America	515	265	51.5	184	35.7	483	246	50.9	166	34.4	521	258	49.5	176	33.8
Canada	153	99	64.7	75	49.0	130	91	70.0	65	50.0	145	96	66.2	73	50.3
Mexico	84	30	35.7	21	25.0	86	31	36.0	17	19.8	94	34	36.2	17	18.1
Argentina	35	21	60.0	16	45.7	29	11	37.9	7	24.1	45	31	68.9	21	46.7
Brazil	82	26	31.7	15	18.3	77	27	35.1	22	28.6	108	23	21.3	16	14.8
Chile	23	9	39.1	7	30.4	23	12	52.2	6	26.1	19	9	47.4	7	36.8
Colombia	28	15	53.6	6	21.4	21	10	47.6	6	28.6	20	11	55.0	8	40.0
Peru	10	7	70.0	5	50.0	12	8	66.7	6	50.0	11	6	54.5	4	36.4
Other	100	58	58.0	39	39.0	105	56	53.3	37	35.2	79	48	60.8	30	38.0

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Appendix table 2-37.

Foreign doctoral recipients from U.S. universities who plan to stay in the United States, by field and region/country of origin: 1990-96

Region /country of origin	1990					1991					1992					1993				
	Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.	
		No.	%	No.	%		No.	%	No.	%		No.	%	No.	%		No.	%	No.	%
	Social sciences																				
Asia	573	179	31.2	128	22.3	668	263	39.4	160	24.0	705	283	40.1	152	21.6	762	328	43.0	166	21.8
China	59	34	57.6	23	39.0	86	63	73.3	31	36.0	113	94	83.2	44	38.9	176	140	79.5	61	34.7
Taiwan	78	22	28.2	12	15.4	105	40	38.1	25	23.8	99	29	29.3	11	11.1	107	25	23.4	13	12.1
Japan	72	24	33.3	19	26.4	50	18	36.0	12	24.0	57	19	33.3	8	14.0	61	20	32.8	11	18.0
South Korea	204	36	17.6	26	12.7	251	55	21.9	33	13.1	268	50	18.7	28	10.4	232	38	16.4	13	5.6
India	76	36	47.4	29	38.2	91	57	62.6	43	47.3	90	61	67.8	43	47.8	102	76	74.5	53	52.0
Other	84	27	32.1	19	22.6	85	30	35.3	16	18.8	78	30	38.5	18	23.1	84	29	34.5	15	17.9
Europe	175	88	50.3	65	37.1	229	126	55.0	97	42.4	238	149	62.6	102	42.9	247	124	50.2	85	34.4
Greece	18	10	55.6	6	33.3	29	12	41.4	8	27.6	24	15	62.5	8	33.3	29	18	62.1	11	37.9
United Kingdom	35	23	65.7	15	42.9	44	27	61.4	15	34.1	52	39	75.0	27	51.9	44	28	63.6	19	43.2
Germany	32	19	59.4	17	53.1	28	18	64.3	14	50.0	28	15	53.6	7	25.0	41	23	56.1	16	39.0
Italy	15	6	40.0	3	20.0	29	12	41.4	11	37.9	20	14	70.0	10	50.0	22	7	31.8	5	22.7
France	11	4	36.4	3	27.3	11	6	54.5	6	54.5	12	5	41.7	5	41.7	12	3	25.0	2	16.7
Spain	14	6	42.9	6	42.9	18	10	55.6	9	50.0	23	12	52.2	10	43.5	25	5	20.0	4	16.0
Other	50	20	40.0	15	30.0	70	41	58.6	34	48.6	79	49	62.0	35	44.3	74	40	54.1	28	37.8
N./S. America	199	80	40.2	62	31.2	225	97	43.1	72	32.0	246	119	48.4	69	28.0	251	107	42.6	72	28.7
Canada	81	38	46.9	34	42.0	88	37	42.0	27	30.7	95	53	55.8	40	42.1	103	51	49.5	40	38.8
Mexico	14	5	35.7	2	14.3	26	13	50.0	10	38.5	30	9	30.0	2	6.7	28	9	32.1	5	17.9
Argentina	11	5	45.5	5	45.5	16	9	56.3	5	31.3	27	12	44.4	5	18.5	12	4	33.3	1	8.3
Brazil	23	2	8.7	1	4.3	18	6	33.3	5	27.8	23	9	39.1	5	21.7	30	10	33.3	6	20.0
Chile	17	5	29.4	3	17.6	13	3	23.1	3	23.1	14	5	35.7	3	21.4	13	3	23.1	2	15.4
Colombia	5	4	80.0	2	40.0	12	6	50.0	4	33.3	6	4	66.7	2	33.3	6	2	33.3	2	33.3
Peru	5	3	60.0	1	20.0	10	7	70.0	5	50.0	14	9	64.3	6	42.9	12	6	50.0	2	16.7
Other	43	18	41.9	14	32.6	42	16	38.1	13	31.0	37	18	48.6	6	16.2	47	22	46.8	14	29.8

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Appendix table 2-37.

Foreign doctoral recipients from U.S. universities who plan to stay in the United States, by field and region/country of origin: 1990-96

Region/country of origin	1994					1995					1996				
	Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.	
		No.	%	No.	%		No.	%	No.	%		No.	%	No.	%
								Social sciences							
Asia	845	408	48.3	204	24.1	641	389	46.3	197	23.4	829	379	45.7	216	26.1
China	208	186	89.4	81	38.9	177	150	84.7	69	39.0	191	154	80.6	88	46.1
Taiwan	118	21	17.8	9	7.6	122	30	24.6	9	7.4	116	27	23.3	6	5.2
Japan	77	33	42.9	22	28.6	74	32	43.2	25	33.8	79	35	44.3	19	24.1
South Korea	241	51	21.2	26	10.8	242	48	19.8	17	7.0	221	41	18.6	22	10.0
India	111	80	72.1	50	45.0	135	97	71.9	59	43.7	131	91	69.5	61	46.6
Other	90	37	41.1	16	17.8	91	32	35.2	18	19.8	91	31	34.1	20	22.0
Europe	224	124	55.4	82	36.6	244	148	60.7	101	41.4	266	139	52.3	91	34.2
Greece	24	8	33.3	5	20.8	26	13	50.0	7	26.9	22	13	59.1	9	40.9
United Kingdom	42	27	64.3	15	35.7	46	33	71.7	26	56.5	50	35	70.0	24	48.0
Germany	52	36	69.2	29	55.8	42	29	69.0	22	52.4	41	23	56.1	15	36.6
Italy	31	19	61.3	10	32.3	23	12	52.2	7	30.4	30	10	33.3	6	20.0
France	11	7	63.6	4	36.4	12	5	41.7	2	16.7	11	5	45.5	2	18.2
Spain	14	6	42.9	6	42.9	12	8	66.7	7	58.3	21	10	47.6	5	23.8
Other	50	21	42.0	13	26.0	83	48	57.8	30	36.1	91	43	47.3	30	33.0
N./S. America	239	103	43.1	67	28.0	209	101	48.3	68	32.5	253	124	49.0	82	32.4
Canada	86	40	46.5	30	34.9	102	55	53.9	38	37.3	87	55	63.2	36	41.4
Mexico	28	8	28.6	4	14.3	16	5	31.3	3	18.8	27	10	37.0	7	25.9
Argentina	14	10	71.4	7	50.0	13	7	53.8	6	46.2	14	5	35.7	2	14.3
Brazil	26	8	30.8	6	23.1	14	6	42.9	3	21.4	32	11	34.4	9	28.1
Chile	11	2	18.2	1	9.1	7	0	0.0	0	0.0	9	2	22.2	1	11.1
Colombia	8	6	75.0	3	37.5	14	2	14.3	1	7.1	15	6	40.0	2	13.3
Peru	12	4	33.3	3	25.0	9	3	33.3	2	22.2	14	11	78.6	8	57.1
Other	54	25	46.3	13	24.1	34	23	67.6	15	44.1	55	24	43.6	17	30.9

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Appendix table 2-37.

Foreign doctoral recipients from U.S. universities who plan to stay in the United States, by field and region/country of origin: 1990-96

Region /country of origin	1990					1991					1992					1993				
	Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.	
		No.	%	No.	%		No.	%	No.	%		No.	%	No.	%		No.	%	No.	%
										Engineering										
Asia	1,607	762	47.4	503	31.3	2,002	1,150	57.4	649	32.4	2,123	1,303	61.4	651	30.7	2,209	1,326	60.0	609	27.6
China	328	179	54.6	98	29.9	477	368	77.1	178	37.3	508	443	87.2	183	36.0	543	487	89.7	196	36.1
Taiwan	476	208	43.7	134	28.2	597	294	49.2	163	27.3	637	320	50.2	143	22.4	592	235	39.7	105	17.7
Japan	17	5	29.4	4	23.5	29	7	24.1	6	20.7	25	6	24.0	3	12.0	23	6	26.1	1	4.3
South Korea	360	103	28.6	66	18.3	434	148	34.1	78	18.0	437	131	30.0	65	14.9	484	161	33.3	63	13.0
India	314	211	67.2	162	51.6	357	272	76.2	191	53.5	405	335	82.7	222	54.8	448	368	82.1	209	46.7
Other	112	56	50.0	39	34.8	108	61	56.5	33	30.6	111	68	61.3	35	31.5	119	69	58.0	35	29.4
Europe	205	92	44.9	64	31.2	200	97	48.5	61	30.5	202	107	53.0	68	33.7	237	137	57.8	87	36.7
Greece	57	28	49.1	20	35.1	70	36	51.4	22	31.4	59	31	52.5	17	28.8	68	37	54.4	27	39.7
United Kingdom	15	10	66.7	7	46.7	15	10	66.7	6	40.0	17	14	82.4	11	64.7	18	16	88.9	12	66.7
Germany	15	5	33.3	4	26.7	8	4	50.0	0	0.0	18	10	55.6	7	38.9	23	14	60.9	7	30.4
Italy	14	6	42.9	3	21.4	12	2	16.7	2	16.7	10	4	40.0	2	20.0	10	7	70.0	5	50.0
France	27	12	44.4	8	29.6	19	6	31.6	6	31.6	25	10	40.0	4	16.0	32	11	34.4	4	12.5
Spain	8	1	12.5	1	12.5	4	1	25.0	1	25.0	6	3	50.0	2	33.3	8	2	25.0	2	25.0
Other	69	30	43.5	21	30.4	72	38	52.8	24	33.3	67	35	52.2	25	37.3	78	50	64.1	30	38.5
N./S. America	168	75	44.6	56	33.3	170	96	56.5	67	39.4	160	84	52.5	55	34.4	179	83	46.4	45	25.1
Canada	41	22	53.7	16	39.0	54	32	59.3	24	44.4	46	27	58.7	20	43.5	42	26	61.9	18	42.9
Mexico	25	10	40.0	7	28.0	22	10	45.5	9	40.9	16	5	31.3	4	25.0	27	14	51.9	6	22.2
Argentina	12	6	50.0	4	33.3	12	9	75.0	6	50.0	14	9	64.3	5	35.7	10	6	60.0	3	30.0
Brazil	31	5	16.1	4	12.9	34	15	44.1	9	26.5	31	9	29.0	4	12.9	46	8	17.4	3	6.5
Chile	11	4	36.4	3	27.3	8	2	25.0	2	25.0	10	2	20.0	2	20.0	5	4	80.0	1	20.0
Colombia	8	5	62.5	4	50.0	11	8	72.7	3	27.3	9	6	66.7	4	44.4	8	3	37.5	3	37.5
Peru	6	3	50.0	3	50.0	7	7	100.0	4	57.1	5	5	100.0	3	60.0	10	7	70.0	3	30.0
Other	34	20	58.8	15	44.1	22	13	59.1	10	45.5	29	21	72.4	13	44.8	31	15	48.4	8	25.8

Appendix table 2-37.

Foreign doctoral recipients from U.S. universities who plan to stay in the United States, by field and region/country of origin: 1990-96

Region/country of origin	1994					1995					1996				
	Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.	
		No.	%	No.	%		No.	%	No.	%		No.	%	No.	%
									Engineering						
Asia	2,390	1,521	63.6	675	28.2	2,475	1,708	69.0	792	32.0	2,508	1,780	71.0	1,085	43.3
China	656	603	91.9	226	34.5	773	724	93.7	293	37.9	801	725	90.5	434	54.2
Taiwan	670	306	45.7	133	19.9	616	295	47.9	126	20.5	575	310	53.9	159	27.7
Japan	46	12	26.1	6	13.0	30	6	20.0	4	13.3	32	8	25.0	4	12.5
South Korea	429	143	33.3	52	12.1	344	120	34.9	46	13.4	326	119	36.5	69	21.2
India	480	402	83.8	235	49.0	572	489	85.5	292	51.0	625	539	86.2	376	60.2
Other	109	55	50.5	23	21.1	140	74	52.9	31	22.1	149	79	53.0	43	28.9
Europe	243	143	58.8	89	36.6	280	187	66.8	104	37.1	210	136	64.8	95	45.2
Greece	58	31	53.4	23	39.7	61	42	68.9	20	32.8	47	29	61.7	22	46.8
United Kingdom	15	12	80.0	7	46.7	20	18	90.0	12	60.0	10	7	70.0	5	50.0
Germany	29	19	65.5	11	37.9	37	23	62.2	10	27.0	16	10	62.5	8	50.0
Italy	11	5	45.5	2	18.2	9	5	55.6	2	22.2	8	3	37.5	1	12.5
France	32	16	50.0	7	21.9	24	12	50.0	5	20.8	26	14	53.8	12	46.2
Spain	9	2	22.2	1	11.1	6	2	33.3	1	16.7	8	6	75.0	4	50.0
Other	89	58	65.2	38	42.7	123	85	69.1	54	43.9	95	67	70.5	43	45.3
N./S. America	201	94	46.8	51	25.4	170	70	41.2	42	24.7	215	102	47.4	64	29.8
Canada	36	21	58.3	18	50.0	41	27	65.9	16	39.0	45	31	68.9	21	46.7
Mexico	30	11	36.7	4	13.3	26	9	34.6	6	23.1	37	15	40.5	8	21.6
Argentina	7	6	85.7	5	71.4	7	4	57.1	4	57.1	8	7	87.5	4	50.0
Brazil	49	11	22.4	5	10.2	46	6	13.0	3	6.5	67	19	28.4	12	17.9
Chile	8	3	37.5	3	37.5	8	2	25.0	1	12.5	8	1	12.5	0	0.0
Colombia	12	7	58.3	0	0.0	10	3	30.0	3	30.0	7	3	42.9	3	42.9
Peru	10	9	90.0	4	40.0	5	5	100.0	2	40.0	5	4	80.0	2	40.0
Other	49	26	53.1	12	24.5	27	14	51.9	7	25.9	38	22	57.9	14	36.8

NOTES: Data Include foreign doctoral recipients with either permanent or temporary visas. Doctoral recipients who "plan to stay" think that they will locate in the United States; those with "firm plans" have a postdoctoral research appointment or academic, industrial, or other firm employment in the United States.

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Earned Doctorates, unpublished tabulations, 1997.

See figure 2-19.

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Appendix table 2-38.

1990-91 Foreign doctoral recipients from U.S. universities working in the United States, by degree field and place of origin: 1992-95

Degree field and place of origin	Foreign doctoral recipients	Percent working in the United States			
		1992	1993	1994	1995
Total S&E fields	13,878	45	48	49	47
China	2,779	75	81	87	88
India	1,235	76	76	7	79
Japan	227	18	23	25	13
South Korea	1,912	17	14	13	11
Taiwan	1,824	46	48	45	42
England	142	48	55	55	59
Germany	177	30	2:	34	35
Greece	240	39	43	40	41
Canada	417	35	41	44	46
Mexico	194	26	28	28	30
Physical sciences	4,156	52	54	55	53
China	1,235	78	84	88	90
India	357	70	73	76	73
Japan	57	23	32	32	8
South Korea	496	23	18	18	16
Taiwan	460	51	47	45	43
England	49	53	58	55	60
Germany	94	32	31	39	41
Greece	72	47	56	52	49
Canada	116	37	46	46	49
Mexico	48	22	32	30	30
Life sciences	2,729	38	42	46	45
China	652	64	72	86	85
India	158	71	61	73	73
Japan	31	23	32	32	8
South Korea	268	20	19	16	11
Taiwan	288	37	47	38	33
England	29	38	50	57	65
Germany	32	20	20	24	24
Greece	27	38	38	34	43
Canada	110	30	38	43	46
Mexico	73	20	18	21	25
Social sciences	2,188	27	28	28	28
China	133	64	70	69	69
India	135	53	55	56	54
Japan	99	15	16	19	14
South Korea	424	8	7	7	7
Taiwan	160	28	25	21	21
England	44	38	47	47	49
Germany	32	34	38	34	34
Greece	30	33	25	25	21
Canada	119	34	37	42	41
Mexico and Brazil	31	20	23	23	23
Engineering	4,805	52	54	55	53
China	759	80	87	91	91
India	585	86	87	89	89
Japan	40	17	20	23	20
South Korea	724	18	14	11	10
Taiwan	916	50	53	51	48
England	20	73	73	73	73
Germany	19	33	26	26	26
Greece	111	36	40	38	41
Canada	72	43	42	43	49
Mexico	42	44	44	42	42

NOTES: Data are for foreign doctoral recipients with temporary visas only. Physical sciences include mathematics and computer sciences. Social sciences include psychology, sociology, and other social sciences.

SOURCE: M.G. Finn, *Stay Rates of Foreign Doctorate Recipients From U.S. Universities, 1995* (Oak Ridge, TN: Oak Ridge Institute for Science and Education, 1997).

See text table 3-17.

Appendix table 2-39.
Postdoctoral appointments in science and engineering, by citizenship status: 1988-95

Field	1988	1989	1990	1991	1992	1993	1994	1995
All postdoctoral appointments								
Total, all surveyed fields[a]	26,083	27,878	29,515	30,800	32,682	34,263	36,301	35,379
Total, science and engineering fields	19,687	20,864	21,770	22,808	23,825	24,599	25,727	25,995
Total sciences	18,002	18,952	19,831	20,565	21,474	22,165	23,137	23,367
Total engineering	1,685	1,912	1,939	2,243	2,351	2,434	2,590	2,628
To U.S. citizens								
Total, all surveyed fields[a]	14,392	14,826	15,090	15,097	15,764	16,684	17,939	18,002
Total, science and engineering fields	10,423	10,654	10,651	10,775	11,154	11,591	12,433	12,778
Total sciences	9,838	10,003	10,043	10,130	10,393	10,750	11,429	11,791
Total engineering	585	651	608	645	761	841	1,004	987
To non-U.S. citizens								
Total, all surveyed fields[a]	11,691	13,052	14,425	15,703	16,918	17,579	18,362	17,377
Total, science and engineering fields	9,264	10,210	11,119	12,033	12,671	13,008	13,294	13,217
Total sciences	8,164	8,949	9,788	10,435	11,081	11,415	11,708	11,576
Total engineering	1,100	1,261	1,331	1,598	1,590	1,593	1,586	1,641

[a] Survey includes all science, engineering, and health fields.

SOURCE: National Science Foundation, Science Resources Studies Division, *Graduate Students and Postdoctorates in Science and Engineering, Fall 1995*, NSF 97-312 (Arlington, VA: 1997).

Science & Engineering Indicators – 1998

Appendix table 2-40.
Foreign-born S&E faculty in U.S. higher education, by teaching field and region of origin: 1993

Region of origin	Total S&E	Physical sciences	Life sciences	Math & computer sciences	Social sciences	Engineering
		Number				
Total S&E faculty	242,812	37,693	59,654	45,545	72,910	27,010
U.S. origin	193,606	29,550	51,382	33,122	62,522	17,029
Foreign origin	49,206	8,143	8,273	12,423	10,388	9,980
Asia	22,608	3,630	4,081	5,702	3,868	5,327
Europe	11,693	2,815	2,202	2,900	2,085	1,692
North America	2,206	330	473	261	958	185
Central America	671	25	188	59	139	261
Caribbean	747	128	134	87	366	32
South America	2,621	128	298	408	813	964
Africa	2,621	128	298	408	813	964
Oceania	499	40	103	115	140	101
Abroad, not specified	6,462	1,000	308	2,356	1,589	1,210
		Percent				
Total S&E faculty	100.0	100.0	100.0	100.0	100.0	100.0
U.S. origin	79.7	78.4	86.1	72.7	85.8	63.1
Foreign origin	20.3	21.6	13.9	27.3	14.2	36.9
Asia	9.3	9.6	6.8	12.5	5.3	19.7
Europe	4.8	7.5	3.7	6.4	2.9	6.3
North America	0.9	0.9	0.8	0.6	1.3	0.7
Central America	0.3	0.1	0.3	0.1	0.2	0.0
Caribbean	0.3	0.3	0.2	0.2	0.5	0.1
South America	0.6	0.1	0.7	1.1	0.5	0.8
Africa	1.1	0.3	0.5	0.9	1.1	3.6
Oceania	0.2	0.1	0.2	0.3	0.2	0.4
Abroad, not specified	2.7	2.7	0.5	5.2	2.2	4.5

NOTES: Data include scientists and engineers whose first job is in S&E postsecondary teaching at four-year college and universities in the United States Data exclude scientists and engineers who teach in S&E fields in two-year or community colleges, or who teach as a secondary job.

SOURCE: National Science Foundation, Science Resources Studies Division, SESTAT database, unpublished tabulations.

See figure 2-20 and text table 2-11.

Science & Engineering Indicators – 1998

Appendix table 2-41.
Foreign-born female S&E faculty in U.S. higher education, by teaching field and region of origin: 1993

Region of origin	Total S&E	Physical sciences	Life sciences	Math & computer sciences	Social sciences	Engineering
Total foreign-born female S&E faculty	9,897	1,712	2,400	2,346	2,777	662
Asia	4,509	873	1,118	1,157	1,061	300
Europe	1,899	368	547	398	405	181
North America	368	29	185	7	138	9
Central America	49	0	8	8	29	4
Caribbean	225	24	85	0	116	0
South America	333	27	160	19	28	99
Africa	260	10	81	77	66	26
Oceania	123	0	9	0	105	9
Abroad, not specified	2,131	381	207	680	829	34

NOTES: Data include scientists and engineers whose first job is in S&E postsecondary teaching at four-year college and universities in the United States. Data exclude scientists and engineers who teach in S&E fields in two-year or community colleges, or who teach as a secondary job.

SOURCE: National Science Foundation, Science Resources Studies Division, SESTAT database, unpublished tabulations.

Science & Engineering Indicators – 1998

Appendix table 2-42.
Major places of origin for foreign-born S&E faculty in U.S. higher education, by field: 1993

Place of origin	Total S&E	Physical sciences	Life sciences	Math & computer sciences	Social sciences	Engineering
Total S&E faculty	242,812	37,693	59,654	45,545	72,910	27,010
		Total				
Total S&E faculty from major places of origin	23,762	4,706	3,754	5,394	4,589	5,319
India	5,696	597	796	1,648	1,032	1,6237
China	4,263	970	773	1,261	386	873
United Kingdom	3,149	1,076	476	380	487	730
Taiwan	2,491	507	350	688	234	712
Canada	2,206	330	473	260	958	185
South Korea	2,163	511	311	426	571	344
Germany	1,604	410	400	236	553	5
Iran	1,369	113	101	268	269	618
Greece	821	192	74	227	99	229
		Female				
Total S&E faculty from major places of origin	4,316	984	1,152	947	939	294
India	1,168	125	241	423	274	105
China	1,031	371	309	212	52	87
United Kingdom	251	57	87	23	73	11
Taiwan	638	214	128	228	65	3
Canada	368	29	185	7	138	9
South Korea	201	30	16	14	141	0
Germany	289	64	105	30	90	0
Iran	143	17	7	10	98	11
Greece	227	77	74	0	8	68

NOTES: Data include scientists and engineers whose first job is in S&E postsecondary teaching at four-year college and universities in the United States. Data exclude scientists and engineers who teach in S&E fields in two-year or community colleges, or who teach as a secondary job.

SOURCE: National Science Foundation, Science Resources Studies Division, SESTAT database, unpublished tabulations.

See text table 2-11.

Science & Engineering Indicators – 1998

Appendix table 2-43.
S&E doctoral degrees earned by Asian students at U.S. universities, by place of origin: 1986-95

Place of origin	Cumulative 1986-95	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Total	44,931	2,139	2,473	2,762	3,099	4,315	5,239	5,725	5,943	6,549	6,687
China	14,088	198	293	480	620	1,150	1,793	2,045	2,227	2,531	2,751
Hong Kong	952	73	87	81	93	94	121	109	109	95	90
India	7,554	469	503	520	536	711	752	861	933	1,065	1,204
Japan	1,276	111	83	104	106	147	125	132	132	182	154
South Korea	8,821	402	549	621	753	979	1,114	1,126	1,123	1,150	1,004
Taiwan	10,276	709	790	786	857	1,012	1,127	1,242	1,213	1,301	1,239
Thailand	956	109	95	98	76	111	93	87	77	97	113
Other Asia	1,008	68	73	72	58	111	114	123	129	128	132

NOTE: Data include foreign students with either temporary or permanent visas.

SOURCE: National Science Foundation, Science Resources Studies Division, *Selected Data on Science and Engineering Doctorate Awards: 1995*, NSF 96-303 (Arlington, VA: 1996).

See text table 2-12.

Science & Engineering Indicators – 1998

Appendix table 3-1.

Number, education and employment status, and median income of 1993 and 1994 bachelor's and master's degree recipients, by degree field: 1995

			Not full-time student			
Degree field	Graduates (thousands)[a]	Full-time student	Employed in S&E occupation	Employed in non-S&E occupation	Unemployed	Median salary[b]
Bachelor's degree recipients						
TOTAL SCIENCE & ENGINEERING	700.1	23	19	52	6	25,000
Total science	581.7	25	10	59	6	22,900
Mathematics & computer sciences	69.2	13	32	51	4	30,000
Life sciences	121.6	37	10	47	5	22,000
Physical sciences	33.2	39	27	30	4	25,000
Social sciences	357.8	21	5	67	7	21,000
Total engineering	118.4	15	62	20	4	33,500
Aerospace	4.4	25	43	29	3	30,000
Chemical	9.6	22	58	14	6	37,800
Civil & architectural	18.0	13	68	17	3	30,000
Electrical, electronics, computer & communications	38.6	12	64	21	4	35,000
Industrial	6.4	10	59	28	3	34,000
Mechanical	28.9	13	66	17	4	34,000
Other	12.5	25	50	21	3	32,000
Master's degree recipients						
TOTAL SCIENCE & ENGINEERING	146.3	24	43	28	5	39,000
Total science	99.7	26	32	36	5	35,000
Mathematics & computer sciences	24.3	14	54	28	4	43,200
Life sciences	15.0	36	30	29	5	31,200
Physical sciences	9.7	39	41	16	5	35,000
Social sciences	50.7	27	21	46	6	30,000
Total engineering	46.6	19	65	11	4	44,000
Aerospace	1.7	28	56	14	2	43,600
Chemical	1.8	25	67	5	3	44,000
Civil & architectural	6.1	13	77	7	3	39,500
Electrical, electronics, computer & communications	16.4	21	65	9	5	46,000
Industrial	3.0	9	66	23	2	44,000
Mechanical	7.4	20	67	9	3	43,00
Other	10.1	20	59	16	5	45,000

NOTES: For graduates with more than one eligible degree at the same level (bachelor's/master's), the most recent degree at that level was used. Details may not sum to totals because of rounding. Percentages were calculated on unrounded data. Education and employment status are as of April 1995.

[a] Includes people who received a bachelor's or master's degree in science or engineering from a U.S. college or university between July 1992 and June 1994.

[b] Salary data are provided only for graduates who are employed full time; data for self-employed and full-time students are not included. Median salaries are rounded to the nearest hundred dollars.

SOURCE: National Science Foundation, Science Resources Studies Division, National Survey of Recent College Graduates, 1995.

Science & Engineering Indicators – 1998

Appendix table 3-2.

Employed 1993 and 1994 S&E bachelor's and master's degree recipients, by degree field and sector of employment: 1995

		Sector of employment (percentages)[a]						
Degree field	Total employed (thousands)	4-year college & university	Other educational institution	Private for-profit	Self-employed	Private not-for-profit	Federal Government	State & local government
Bachelor's degree recipients								
Total science & engineering	585.6	13	9	59	2	6	4	6
Total science	476.7	14	10	56	3	7	4	7
Total engineering	108.9	11	1	75	2	1	7	4
Master's degree recipients								
Total science & engineering	128.4	23	9	47	2	6	7	6
Total science	86.0	26	12	38	2	9	5	7
Total engineering	42.4	17	1	66	1	1	10	4

NOTES: For graduates with more than one eligible degree at the same level (bachelor's/master's), the most recent degree at that level was used. Details may not sum to totals because of rounding. Percentages were calculated on unrounded data.

[a] This is the sector of employment in which the respondent was working on his or her primary job held on April 15, 1995. People working in four-year colleges and universities or university-affiliated medical schools or research organizations were classified as employed in the "four-year college and university" sector. Those working in elementary, middle, secondary, or two-year colleges or other educational institutions were categorized in the "other educational" sector. Those reporting that they were self-employed but in an incorporated business were classified in the "private for-profit" sector.

SOURCE: National Science Foundation, Science Resources Studies Division, National Survey of Recent College Graduates, 1995.

Science & Engineering Indicators – 1998

Appendix table 3-3.

Employment status of scientists and engineers, by broad occupation and highest degree received: 1995

Occupation	Total	Employed	Unemployed
	All degree recipients		
All S&E occupations	3,256,200	3,185,600	70,600
Computer and math scientists	966,200	949,500	16,800
Life scientists	311,500	305,300	6,200
Physical scientists	281,800	274,300	7,500
Social scientists	321,400	317,500	3,900
Engineers	1,375,200	1,339,000	36,200
	Bachelor's degree recipients		
All S&E occupations	1,883,400	1,844,000	39,400
Computer and math scientists	635,300	625,000	10,400
Life scientists	123,900	121,500	2,400
Physical scientists	131,000	128,100	2,900
Social scientists	61,600	60,600	1,000
Engineers	931,500	908,800	22,800
	Master's degree recipients		
All S&E occupations	915,800	892,700	23,000
Computer and math scientists	273,600	268,000	5,600
Life scientists	65,200	64,000	1,200
Physical scientists	69,800	67,200	2,700
Social scientists	138,000	135,800	2,300
Engineers	369,100	357,900	11,300
	Ph.D. degree recipients		
All S&E occupations	425,700	418,300	7,500
Computer and math scientists	54,600	53,800	800
Life scientists	104,500	102,400	2,000
Physical scientists	80,600	78,900	1,800
Social scientists	113,900	113,300	700
Engineers	72,100	69,900	2,200
	Other professional degree recipients		
All S&E occupations	31,300	30,600	700
Computer and math scientists	2,700	2,700	–
Life scientists	17,900	17,400	600
Physical scientists	300	200	100
Social scientists	7,900	7,900	–
Engineers	2,500	2,500	–

– = weighted value of less than 50

SOURCE: National Science Foundation, Science Resources Studies Division, 1995 SESTAT (Scientists and Engineers Statistics Data System) Surveys of Science and Engineering College Graduates.

See figure 3-3.

Science & Engineering Indicators – 1998

Appendix table 3-4.

Number of employed scientists and engineers, by occupation and highest degree received: 1995

Occupation	Total	Bachelor's degree	Master's degree	Ph.D. degree	Other professional degree
All S&E occupations	3,185,600	1,844,000	892,700	418,300	30,600
Computer and math scientists	949,500	625,000	268,000	53,800	2,700
Computer and information scientists	839,600	595,200	219,800	22,100	2,500
Mathematicians	37,900	16,300	14,000	7,600	–
Postsecondary teachers	72,000	13,500	34,200	24,100	200
Life scientists	305,300	121,500	64,000	102,400	17,400
Agricultural scientists	43,400	24,700	9,300	9,300	100
Biological scientists	168,600	69,700	32,800	57,900	8,200
Environmental life scientists	20,100	13,400	5,800	900	–
Postsecondary teachers	73,200	13,600	16,200	34,400	9,000
Physical scientists	274,300	128,100	67,200	78,900	200
Chemists, except biochemists	111,400	65,300	20,200	25,900	100
Earth scientists	70,700	36,100	24,300	10,400	–
Physicists and astronomers	29,000	7,100	7,700	14,100	–
Other physical scientists	17,000	9,300	5,100	2,600	100
Postsecondary teachers	46,200	10,300	9,900	25,900	–
Social scientists	317,500	60,600	135,800	113,300	7,900
Economists	33,100	10,900	15,100	7,000	100
Political scientists	8,900	5,100	2,600	1,200	–
Psychologists	167,200	25,400	88,700	48,200	4,900
Sociologists and anthropologists	16,000	7,800	5,200	3,000	–
S&T historians and other social scientists	12,600	3,800	4,900	3,100	900
Postsecondary teachers	79,700	7,600	19,300	50,800	2,000
Engineers	1,339,000	908,800	357,900	69,900	2,500
Aerospace engineers	72,800	42,600	25,900	4,200	100
Chemical engineers	71,100	46,100	19,200	5,800	–
Civil and architectural engineers	198,900	143,400	51,000	3,900	600
Electrical and related engineers	357,400	241,000	102,000	13,200	1,200
Industrial engineers	69,600	52,400	16,400	800	–
Mechanical engineers	255,100	191,600	55,000	8,100	300
Other engineers	282,800	186,300	79,900	16,400	200
Postsecondary teachers	31,300	5,300	8,400	17,500	–

– = weighted value of less than 50; S&T = science and technology

SOURCE: National Science Foundation, Science Resources Studies Division, 1995 SESTAT (Scientists and Engineers Statistics Data System) Surveys of Science and Engineering College Graduates.

See text table 3-11.

Science & Engineering Indicators – 1998

Appendix table 3-5.

Number of employed scientists and engineers, by occupation and degree field: 1995

Occupation	All fields	Math & computer science	Life sciences	Physical sciences	Social sciences	Engineering	Non-S&E fields
All S&E occupations	3,185,600	446,500	297,200	312,900	384,400	1,193,700	550,800
Computer and math scientists	949,500	406,600	21,700	36,900	88,500	145,700	250,000
Computer and information scientists	839,600	345,300	19,100	33,200	80,500	138,000	223,600
Mathematicians	37,900	17,500	1,800	2,300	5,800	3,200	7,200
Postsecondary teachers	72,000	43,900	700	1,400	2,200	4,500	19,300
Life scientists	305,300	1,400	217,100	19,500	14,400	3,800	49,100
Agricultural scientists	43,400	300	33,300	1,600	1,700	500	6,000
Biological scientists	168,600	1,000	120,300	15,000	8,000	2,700	21,500
Environmental life scientists	20,100	–	14,100	400	1,600	100	3,800
Postsecondary teachers	73,200	100	49,400	2,400	3,100	400	17,800
Physical scientists	274,300	4,800	33,400	200,800	7,500	14,200	13,600
Chemists, except biochemists	111,400	1,100	17,700	80,900	1,100	4,600	6,100
Earth scientists	70,700	1,700	4,600	56,300	2,000	4,100	2,000
Physicists and astronomers	29,000	600	700	23,200	100	2,800	1,600
Other physical scientists	17,000	500	6,400	4,500	2,700	1,400	1,500
Postsecondary teachers	46,200	900	4,100	35,900	1,600	1,200	2,400
Social scientists	317,500	1,700	3,500	1,100	253,100	1,700	56,500
Economists	33,100	1,000	700	200	21,900	1,100	8,200
Political scientists	8,900	–	–	–	8,700	–	100
Psychologists	167,200	100	700	300	137,100	200	28,800
Sociologists and anthropologists	16,000	200	500	400	14,200	100	600
S&T historians & other social scientists	12,600	200	600	100	7,900	200	3,600
Postsecondary teachers	79,700	200	1,000	100	63,300	200	15,000
Engineers	1,339,000	32,000	21,500	54,600	20,900	1,028,400	181,700
Aerospace engineers	72,800	2,700	300	4,100	1,000	52,400	12,200
Chemical engineers	71,100	100	900	4,300	–	59,100	6,600
Civil and architectural engineers	198,900	1,000	800	1,800	2,500	175,300	17,500
Electrical and related engineers	357,400	14,900	2,000	12,900	4,500	274,500	48,600
Industrial engineers	69,600	2,100	1,300	3,100	4,500	40,700	18,000
Mechanical engineers	255,100	1,900	600	2,700	700	215,500	33,600
Other engineers	282,800	8,500	15,400	24,400	7,400	184,300	42,800
Postsecondary teachers	31,300	700	200	1,200	200	26,600	2,500

— = weighted value of less than 50; S&T = science and technology

SOURCE: National Science Foundation, Science Resources Studies Division, 1995 SESTAT (Scientists and Engineers Statistics Data System) Surveys of Science and Engineering College Graduates.

See text table 3-12.

Science & Engineering Indicators – 1998

Appendix table 3-6.
Employed scientists and engineers, by age group and highest degree received: 1995

Age group	Total	Bachelor's degree	Master's degree	Ph.D. degree	Other professional degree
Total	3,185,600	1,844,000	892,700	418,300	30,600
		Percentages			
Under 25	2.3	3.7	0.6	0.1	0.1
25-29	11.1	14.8	8.2	1.3	2.6
30-34	17.3	19.1	16.2	12.0	9.0
35-39	18.1	18.4	17.9	17.4	20.1
40-44	16.0	15.1	17.4	16.5	16.5
45-49	14.0	12.0	16.3	17.6	20.9
50-54	9.1	7.0	10.8	14.7	8.6
55-59	6.0	4.5	7.1	10.1	6.8
60-64	3.5	3.1	3.4	5.4	7.7
Over 64	2.5	2.4	2.1	5.0	7.8

SOURCE: National Science Foundation, Science Resources Studies Division, 1995 SESTAT (Scientists and Engineers Statistics Data System) Surveys of Science and Engineering College Graduates.

See figure 3-4.

Science & Engineering Indicators – 1998

Appendix table 3-7.

Number of employed scientists and engineers, by sector of employment and broad occupation: 1995

Sector	Total	Computer & math scientists	Life scientists	Physical scientists	Social scientists	Engineers
			All degree recipients			
Total, all sectors	3,185,600	949,500	305,300	274,300	317,500	1,339,000
Four-year college & university	291,100	41,000	84,300	51,100	71,900	42,800
Other educational institution	275,200	83,000	64,700	28,500	67,600	31,400
Private for-profit	1,970,300	683,200	75,600	138,600	57,600	1,015,300
Self-employed	113,800	23,600	7,400	6,500	42,600	33,800
Private not-for-profit	91,000	27,600	11,000	5,600	33,700	13,200
Federal Government	252,400	53,300	37,700	27,600	17,100	116,600
State & local government	191,700	37,900	24,600	16,400	27,000	85,900
			Bachelor's degree recipients			
Total, all sectors	1,844,000	625,000	121,500	128,100	60,600	908,800
Four-year college & university	63,400	10,500	20,500	11,800	10,800	9,800
Other educational institution	85,900	34,700	20,000	8,700	8,400	14,200
Private for-profit	1,324,800	482,800	39,200	78,800	16,100	708,000
Self-employed	48,800	16,000	3,600	3,100	2,800	23,400
Private not-for-profit	41,100	19,500	4,300	2,200	8,700	6,300
Federal Government	150,400	35,100	17,100	12,400	5,700	80,100
State & local government	129,500	26,400	16,800	11,200	8,100	66,900
			Master's degree recipients			
Total, all sectors	892,700	268,000	64,000	67,200	135,800	357,900
Four-year college & university	45,800	10,000	6,700	7,000	11,400	10,800
Other educational institution	128,800	39,900	19,900	12,800	42,000	14,200
Private for-profit	524,300	179,400	16,700	32,600	26,100	269,600
Self-employed	39,500	6,200	2,100	2,100	21,000	8,100
Private not-for-profit	31,700	6,500	2,200	1,000	16,900	5,200
Federal Government	70,800	15,400	10,600	7,400	5,600	31,800
State & local government	51,800	10,600	5,900	4,400	12,800	18,200
			Ph.D. degree recipients			
Total, all sectors	418,300	53,800	102,400	78,900	113,300	69,900
Four-year college & university	181,300	20,400	56,800	32,400	49,700	22,100
Other educational institution	45,400	8,300	12,900	7,100	14,100	3,000
Private for-profit	114,600	18,700	17,800	27,200	14,900	36,000
Self-employed	23,100	1,500	1,300	1,300	16,900	2,100
Private not-for-profit	16,300	1,600	3,900	2,500	6,700	1,700
Federal Government	28,400	2,500	8,300	7,700	5,600	4,300
State & local government	9,300	900	1,600	700	5,400	700
			Other professional degree recipients			
Total, all sectors	30,600	2,700	17,400	200	7,900	2,500
Four-year college & university	600	–	400	–	–	100
Other educational institution	15,100	100	11,900	–	3,100	–
Private for-profit	6,600	2,200	2,000	100	600	1,600
Self-employed	2,300	–	300	–	1,900	100
Private not-for-profit	2,000	–	700	–	1,300	–
Federal Government	2,800	300	1,700	100	300	400
State & local government	1,200	–	300	–	800	100

– = weighted value of less than 50

SOURCE: National Science Foundation, Science Resources Studies Division, 1995 SESTAT (Scientists and Engineers Statistics Data System) Surveys of Science and Engineering College Graduates.

Science & Engineering Indicators – 1998

Appendix table 3-8.
Median annual salaries of employed scientists and engineers, by occupation and highest degree received: 1995
(Dollars)

Occupation	Total	Bachelor's degree	Master's degree	Ph.D. degree	Other professional degree
All S&E occupations	50,000	48,000	53,000	58,000	69,000
Computer and math scientists	50,000	49,000	55,000	58,000	63,000
Computer and information scientists	50,000	49,000	57,000	65,000	63,000
Mathematicians	53,000	47,700	55,200	65,000	NA
Postsecondary teachers	41,000	30,000	32,300	50,500	44,000
Life scientists	42,000	35,000	40,000	53,000	100,000
Agricultural scientists	41,000	38,800	36,000	54,000	44,000
Biological scientists	40,000	31,600	40,900	52,000	90,000
Environmental life scientists	40,000	37,000	43,000	59,000	NA
Postsecondary teachers	49,200	28,000	35,000	54,600	100,000
Physical scientists	47,000	40,000	48,000	60,000	24,000
Chemists, except biochemists	47,000	40,000	50,000	64,100	52,000
Earth scientists	45,000	40,000	49,000	62,500	NA
Physicists and astronomers	55,800	42,000	52,000	65,000	NA
Other physical scientists	43,900	37,400	48,000	63,500	24,000
Postsecondary teachers	45,000	15,000	42,000	50,000	17,000
Social scientists	43,000	27,000	39,000	53,000	49,000
Economists	53,500	42,000	59,900	77,000	120,000
Political scientists	33,000	27,200	35,000	61,000	NA
Psychologists	40,000	22,000	37,000	55,000	49,000
Sociologists and anthropologists	32,000	27,000	32,000	50,000	NA
S&T historians and other social scientists	40,000	27,000	39,300	53,700	48,500
Postsecondary teachers	47,000	25,200	36,000	50,000	48,000
Engineers	54,000	50,000	59,000	65,000	50,000
Aerospace engineers	58,000	55,000	60,000	70,000	22,000
Chemical engineers	60,000	55,000	63,000	70,000	NA
Civil and architectural engineers	50,000	48,000	55,000	60,000	50,000
Electrical and related engineers	56,000	52,800	62,000	70,300	53,000
Industrial engineers	50,000	48,000	51,600	66,250	NA
Mechanical engineers	52,000	50,000	56,000	62,000	50,000
Other engineers	53,000	50,000	60,000	65,000	150,000
Postsecondary teachers	54,000	40,000	42,000	60,000	48,000

NA = not available; S&T = science and technology

NOTE: Median annual salaries are for full-time employees only.

SOURCE: National Science Foundation, Science Resources Studies Division, 1995 SESTAT (Scientists and Engineers Statistics Data System) Surveys of Science and Engineering College Graduates.

See figure 3-5

Appendix table 3-9.

Median annual salaries of employed scientists and engineers, by occupation and degree field: 1995

(Dollars)

Occupation	All fields	Math & computer sciences	Life sciences	Physical sciences	Social sciences	Engineering	Non-S&E fields
All S&E occupations	50,000	50,000	41,000	50,000	45,000	53,500	50,000
Computer & math scientists	50,000	50,000	45,000	55,000	48,500	54,800	49,000
Computer & information scientists	50,000	50,500	45,000	55,000	48,500	54,000	50,000
Mathematicians	53,000	55,000	52,000	55,000	50,000	60,000	49,700
Postsecondary teachers	41,000	42,000	51,500	47,400	35,000	51,000	34,000
Life scientists	42,000	50,000	40,500	40,000	42,000	35,000	48,000
Agricultural scientists	41,000	50,000	40,000	68,000	42,000	37,500	43,000
Biological scientists	40,000	48,700	39,000	37,500	37,000	31,300	45,000
Environmental life scientists	40,000	NA	38,900	45,000	44,500	10,000	37,000
Postsecondary teachers	49,200	60,000	46,800	51,400	48,900	64,000	63,900
Physical scientists	47,000	45,000	37,500	49,200	47,000	48,000	40,000
Chemists, except biochemists	47,000	34,000	35,500	50,000	74,000	44,000	43,000
Earth scientists	45,000	52,000	40,000	47,500	40,000	50,000	38,600
Physicists & astronomers	55,800	58,000	110,000	57,000	52,500	48,000	52,000
Other physical scientists	43,900	39,600	37,400	51,300	47,000	55,800	37,000
Postsecondary teachers	45,000	57,300	34,900	48,000	67,000	43,000	39,000
Social scientists	43,000	41,000	48,200	46,000	42,000	60,000	45,000
Economists	53,500	45,000	60,000	46,000	55,000	67,000	49,300
Political scientists	33,000	NA	28,000	46,000	32,500	NA	40,000
Psychologists	40,000	51,000	30,000	15,500	40,000	NA	40,000
Sociologists & anthropologists	32,000	NA	50,000	50,000	31,700	NA	24,800
S&T historians & other social scientists	40,000	20,000	26,500	53,200	39,300	34,000	46,000
Postsecondary teachers	47,000	80,000	48,200	75,000	46,200	40,000	48,000
Engineers	54,000	54,000	48,500	55,500	47,000	53,500	55,000
Aerospace engineers	58,000	62,900	64,000	67,000	70,000	57,000	58,000
Chemical engineers	60,000	58,000	50,000	59,000	41,000	60,000	65,000
Civil & architectural engineers	50,000	60,000	48,500	48,000	43,000	50,000	55,000
Electrical & related engineers	56,000	53,400	50,000	58,000	65,000	55,900	58,000
Industrial engineers	50,000	51,700	60,000	52,000	47,000	48,400	50,000
Mechanical engineers	52,000	50,000	52,000	53,000	48,000	52,000	54,000
Other engineers	53,000	53,900	45,000	55,000	43,500	53,000	55,000
Postsecondary teachers	54,000	60,000	66,100	63,000	53,500	54,000	42,000

NA = not available; S&T = science and technology

NOTE: Median annual salaries are for full-time employees only.

SOURCE: National Science Foundation, Science Resources Studies Division, 1995 SESTAT (Scientists and Engineers Statistics Data System) Surveys of Science and Engineering College Graduates.

Science & Engineering Indicators – 1998

Appendix table 3-10.

Number of employed scientists and engineers, by occupation, sex, and race/ethnicity: 1995

Occupation	Total	Male	Female	White	Black	Hispanic	Asian/Pacific Islander	Native American
All S&E occupations	3,185,600	2,472,100	713,500	2,673,700	107,500	90,100	304,600	8,000
Computer and math scientists	949,500	674,500	275,000	784,900	39,300	22,800	100,200	1,600
Computer and information scientists	839,600	602,700	236,900	694,100	33,100	20,500	90,400	1,200
Mathematicians	37,900	25,300	12,500	31,600	2,500	600	2,700	100
Postsecondary teachers	72,000	46,500	25,500	59,200	3,600	1,700	7,100	300
Life scientists	305,300	199,400	105,900	257,200	9,700	8,500	29,000	700
Agricultural scientists	43,400	32,300	11,100	37,800	1,500	1,600	2,400	–
Biological scientists	168,600	100,700	67,900	137,100	4,800	4,700	21,500	400
Environmental life scientists	20,100	17,400	2,700	19,500	100	300	–	100
Postsecondary teachers	73,200	49,100	24,100	62,900	3,300	1,900	5,100	100
Physical scientists	274,300	215,200	59,100	232,600	7,800	6,800	26,200	800
Chemists, except biochemists	111,400	82,500	29,000	88,800	5,400	2,300	14,600	400
Earth scientists	70,700	58,100	12,600	64,100	700	2,100	3,500	300
Physicists and astronomers	29,000	25,700	3,300	24,900	300	400	3,300	–
Other physical scientists	17,000	12,400	4,600	15,200	300	600	900	–
Postsecondary teachers	46,200	36,600	9,600	39,600	1,100	1,400	4,000	100
Social scientists	317,500	159,000	158,500	277,900	16,500	9,800	11,800	1,500
Economists	33,100	23,900	9,200	28,200	1,200	1,600	1,900	100
Political scientists	8,900	4,900	4,000	7,200	300	600	800	–
Psychologists	167,200	65,700	101,600	150,200	8,400	4,600	3,100	900
Sociologists and anthropologists	16,000	8,400	7,700	14,600	600	200	600	100
S&T historians and other social scientists	12,600	6,300	6,300	10,600	1,100	300	500	–
Postsecondary teachers	79,700	49,900	29,800	67,200	4,900	2,400	4,700	400
Engineers	1,339,000	1,224,000	115,000	1,121,000	34,200	42,200	137,300	3,400
Aerospace engineers	72,800	68,300	4,500	61,900	1,700	3,000	5,800	300
Chemical engineers	71,100	62,200	8,900	58,600	2,200	2,400	7,900	–
Civil and architectural engineers	198,900	180,900	18,000	164,600	3,600	7,300	22,900	400
Electrical and related engineers	357,400	335,200	22,300	285,400	11,500	12,900	46,700	900
Industrial engineers	69,600	60,600	9,000	60,300	3,100	2,100	3,700	400
Mechanical engineers	255,100	240,300	14,800	218,700	5,600	6,800	22,500	800
Other engineers	282,800	247,500	35,300	248,000	5,600	6,500	22,100	600
Postsecondary teachers	31,300	28,900	2,400	23,500	900	1,100	5,700	100

– = weighted value of less than 50; S&T = science and technology

NOTE: Total includes 1,700 persons whose race/ethnicity category was reported as "other."

SOURCE: National Science Foundation, Science Resources Studies Division, 1995 SESTAT (Scientists and Engineers Statistics Data System) Surveys of Science and Engineering College Graduates.

See figure 3-6 and text table 3-14.

Science & Engineering Indicators – 1998

Appendix table 3-11.

Percentage distribution of employed scientists and engineers, by highest degree received, sex, and race/ethnicity: 1995

Occupation	Total	Male	Female	White	Black	Hispanic	Asian/Pacific Islander	Native American
All degree recipients								
All S&E occupations (total number)	3,185,600	2,472,100	713,500	2,673,700	107,500	90,100	304,600	8,000
Computer and math scientists	29.8	27.3	38.5	29.4	36.6	25.3	32.9	20.0
Life scientists	9.6	8.1	14.8	9.6	9.0	9.4	9.5	8.8
Physical scientists	8.6	8.7	8.3	8.7	7.3	7.5	8.6	10.0
Social scientists	10.0	6.4	22.2	10.4	15.3	10.9	3.9	18.8
Engineers	42.0	49.5	16.1	41.9	31.8	46.8	45.1	42.5
Bachelor's degree recipients								
All S&E occupations (total number)	1,844,000	1,465,700	378,300	1,585,200	70,400	54,900	127,600	4,700
Computer and math scientists	33.9	29.9	49.5	33.5	40.6	31.2	36.2	22.9
Life scientists	6.6	5.1	12.3	6.7	6.1	7.7	5.2	6.3
Physical scientists	6.9	6.4	8.9	7.0	7.6	5.5	5.9	10.9
Social scientists	3.3	2.0	8.3	3.1	8.2	3.7	2.0	6.1
Engineers	49.3	56.6	21.1	49.6	37.4	51.9	50.6	53.7
Master's degree recipients								
All S&E occupations (total number)	892,700	660,300	232,400	725,600	25,800	24,000	115,100	1,700
Computer and math scientists	30.0	28.8	33.5	28.9	35.7	18.3	38.4	20.0
Life scientists	7.2	5.5	12.0	7.4	9.8	4.8	5.5	5.5
Physical scientists	7.5	7.8	6.9	7.7	3.9	9.3	6.5	9.6
Social scientists	15.2	8.4	34.5	16.7	23.8	18.6	3.3	24.5
Engineers	40.1	49.6	13.1	39.3		49.0	46.4	40.4
Ph.D. degree recipients								
All S&E occupations (total number)	418,300	324,500	93,800	337,300	9,500	10,200	59,700	1,400
Computer and math scientists	12.9	13.6	10.3	12.3	11.8	13.1	16.0	11.8
Life scientists	24.5	23.2	28.8	24.7	19.8	24.8	24.1	16.1
Physical scientists	18.9	21.4	10.1	19.1	14.4	15.5	18.7	10.8
Social scientists	27.1	21.7	45.6	29.6	43.4	29.9	9.0	50.9
Engineers	16.7	20.0	5.2	14.2	10.6	16.8	32.1	10.4
Other professional degree recipients								
All S&E occupations (total number)	30,600	21,600	9,100	25,500	1,800	1,100	2,200	100
Computer and math scientists	8.8	11.2	3.1	8.3	16.7	–	13.0	–
Life scientists	56.7	60.0	49.0	54.9	58.3	58.2	76.2	54.2
Physical scientists	0.6	0.9	–	0.7	–	–	0.6	–
Social scientists	26.0	16.9	46.8	28.0	25.0	21.9	1.5	45.8
Engineers	8.1	11.0	1.1	8.1	–	19.9	8.7	–

– = weighted value of less than 50

NOTE: Total includes 1,700 persons whose race/ethnicity category was reported as "other."

SOURCE: National Science Foundation, Science Resources Studies Division, 1995 SESTAT (Scientists and Engineers Statistics Data System) Surveys of Science and Engineering College Graduates.

Science & Engineering Indicators – 1998

Appendix table 3-12.

Employed scientists and engineers, by sector of employment, sex, and race/ethnicity: 1995

Sector	Total	Male	Female	White	Black	Hispanic	Asian/Pacific Islander	Native American
			Number					
Total, all sectors	3,185,600	2,472,100	713,500	2,673,700	107,500	90,100	304,600	8,000
Four-year college & university	291,100	210,700	80,400	234,100	9,000	9,300	37,800	900
Other educational institution	275,200	167,000	108,200	228,900	15,400	8,800	21,500	500
Private for-profit	1,970,300	1,614,400	355,900	1,663,000	54,800	51,700	195,900	4,300
Self-employed	113,800	77,500	36,300	106,100	1,200	1,800	4,300	400
Private not-for-profit	91,000	52,900	38,100	76,800	3,600	3,000	7,100	500
Federal Government	252,400	204,900	47,500	210,800	13,700	8,800	17,800	1,100
State & local government	191,700	144,700	47,000	154,000	9,800	6,700	20,100	400
			Percentage distribution					
Total, all sectors	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Four-year college & university	9.1	8.5	11.3	8.8	8.4	10.3	12.4	11.6
Other educational institution	8.6	6.8	15.2	8.6	14.3	9.7	7.1	6.8
Private for-profit	61.8	65.3	49.9	62.2	51.0	57.4	64.3	53.2
Self-employed	3.6	3.1	5.1	4.0	1.1	2.0	1.4	4.4
Private not-for-profit	2.9	2.1	5.3	2.9	3.4	3.4	2.3	5.7
Federal Government	7.9	8.3	6.7	7.9	12.8	9.8	5.9	13.2
State & local government	6.0	5.9	6.6	5.8	9.1	7.5	6.6	5.1

NOTE: Total includes 1,700 persons whose race/ethnicity category was reported as "other."

SOURCE: National Science Foundation, Science Resources Studies Division, 1995 SESTAT (Scientists and Engineers Statistics Data System) Surveys of Science and Engineering College Graduates.

See figure 3-7.

Science & Engineering Indicators – 1998

Appendix table 3-13.

Median annual salaries of employed scientists and engineers, by occupation, sex, and race/ethnicity: 1995

(Dollars)

Occupation	Total	Male	Female	White	Black	Hispanic	Asian/Pacific Islander	Native American
All S&E occupations	50,000	52,000	42,000	50,400	45,000	47,000	50,000	48,000
Computer and math scientists	50,000	52,000	45,000	50,200	44,000	46,000	50,000	42,900
Computer and information scientists	50,000	52,600	46,100	51,000	45,000	46,500	50,000	48,000
Mathematicians	53,000	55,000	47,700	53,000	50,000	40,000	54,300	42,300
Postsecondary teachers	41,000	45,000	30,000	40,400	39,000	44,000	43,000	42,900
Life scientists	42,000	45,000	34,600	42,600	35,000	37,000	37,000	40,000
Agricultural scientists	41,000	43,000	33,000	42,000	39,000	33,000	40,000	36,000
Biological scientists	40,000	44,000	34,000	40,000	32,000	35,000	36,000	36,900
Environmental life scientists	40,000	41,000	24,000	40,000	45,000	41,000	24,500	54,100
Postsecondary teachers	49,200	53,000	38,000	50,000	35,000	40,000	43,000	75,000
Physical scientists	47,000	50,000	39,600	48,000	42,000	40,000	45,000	32,000
Chemists, except biochemists	47,000	50,000	38,000	48,000	44,000	45,000	44,600	32,000
Earth scientists	45,000	47,500	40,000	46,000	42,000	38,000	40,000	28,500
Physicists and astronomers	55,800	58,000	50,000	58,000	45,000	22,000	47,000	79,500
Other physical scientists	43,900	45,500	43,000	43,900	30,000	30,000	53,000	29,500
Postsecondary teachers	45,000	49,000	35,000	46,000	37,000	45,000	48,000	46,200
Social scientists	43,000	48,000	37,000	43,300	35,000	40,000	45,000	37,000
Economists	53,500	55,500	50,000	52,000	60,000	67,000	60,000	48,000
Political scientists	33,000	34,500	27,200	33,000	20,000	35,000	28,000	NA
Psychologists	40,000	47,000	35,000	40,000	32,000	35,000	32,000	32,000
Sociologists and anthropologists	32,000	38,500	30,000	36,000	32,000	28,500	26,000	12,000
S&T historians and other social scientists	40,000	40,000	42,000	41,500	30,000	32,000	48,000	29,000
Postsecondary teachers	47,000	50,000	40,000	47,800	40,000	42,800	48,000	42,000
Engineers	54,000	55,000	47,000	54,000	48,600	50,000	52,000	53,000
Aerospace engineers	58,000	59,500	49,000	59,000	50,100	50,000	58,000	58,000
Chemical engineers	60,000	60,200	49,700	60,000	60,000	53,000	60,000	41,000
Civil and architectural engineers	50,000	50,000	43,000	50,000	44,000	48,000	51,000	50,000
Electrical and related engineers	56,000	57,000	47,100	57,500	48,000	53,000	52,000	48,000
Industrial engineers	50,000	50,000	45,800	50,000	48,000	45,000	48,000	54,000
Mechanical engineers	52,000	52,500	47,500	52,000	49,000	50,000	52,000	48,000
Other engineers	53,000	54,000	47,000	54,000	48,800	45,000	50,000	50,000
Postsecondary teachers	54,000	55,000	44,300	54,100	53,300	45,000	54,000	60,000

NA = not available; S&T = science and technology

NOTE: Median annual salaries are for full-time employees only.

SOURCE: National Science Foundation, Science Resources Studies Division, 1995 SESTAT (Scientists and Engineers Statistics Data System) Surveys of Science and Engineering College Graduates.

See figures 3-8 and 3-9.

Science & Engineering Indicators – 1998

Appendix table 3-14.

Median annual salaries of employed scientists and engineers, by sector of employment, sex, and race/ethnicity: 1995

Sector	Total	Male	Female	White	Black	Hispanic	Asian/Pacific Islander	Native American
Total, all sectors	50,000	52,000	42,000	50,400	45,000	47,000	50,000	48,000
Four-year college & university	44,000	48,000	33,600	45,000	40,000	38,500	38,000	46,200
Other educational institution	41,000	44,000	35,500	42,000	34,000	40,000	38,000	37,000
Private for-profit	53,000	55,000	46,000	54,000	47,000	50,000	52,000	48,000
Self-employed	53,500	55,000	50,000	54,000	100,000	32,000	50,000	50,000
Private not-for-profit	41,300	49,000	32,000	42,000	26,000	35,000	46,000	25,200
Federal Government	52,000	53,000	47,000	52,000	50,000	51,000	51,300	50,000
State & local government	44,000	45,000	37,000	44,000	38,000	42,000	46,700	32,000

NOTE: Median annual salaries are for full-time employees only.

SOURCE: National Science Foundation, Science Resources Studies Division, 1995 SESTAT (Scientists and Engineers Statistics Data System) Surveys of Science and Engineering College Graduates.

Science & Engineering Indicators – 1998

Appendix table 3-15.
Scientists and engineers engaged in R&D, and per 10,000 labor force population, by country: 1979-94

	United States	Japan	Germany[a]	France	United Kingdom	Italy	Canada
Total engaged in R&D (thousands)							
1979	614.5	291.2	116.9	72.9	NA	46.4	NA
1980	651.1	303.2	120.7	74.9	NA	47.0	NA
1981	683.2	311.0	124.7	85.5	127.0	52.1	40.5
1982	711.8	321.0	NA	90.1	128.0	56.7	44.1
1983	751.6	347.4	130.8	92.7	127.0	63.0	45.6
1984	NA	357.4	NA	98.2	129.0	62.0	48.7
1985	801.9	380.3	143.6	102.3	131.0	63.8	52.5
1986	NA	393.0	NA	105.0	134.0	67.8	56.0
1987	877.8	415.6	165.6	109.4	134.0	70.6	58.3
1988	NA	434.6	NA	115.2	137.0	74.8	60.6
1989	924.2	457.5	176.4	120.4	133.0	76.1	62.0
1990	NA	477.9	NA	123.9	133.0	77.9	65.8
1991	960.4	491.1	241.9	129.8	131.0	75.2	65.2
1992	NA	511.4	234.3	141.7	134.0	74.4	73.1
1993	962.7	526.5	229.8	145.9	140.0	74.4	76.6
1994	NA	541.0	NA	149.2	146.0	75.7	NA
Per 10,000 labor force							
1979	57.7	51.3	43.4	31.4	NA	20.8	NA
1980	60.0	53.1	44.3	32.1	NA	20.8	NA
1981	61.9	54.5	44.0	36.3	47.5	22.9	33.8
1982	63.6	55.6	NA	37.9	48.0	24.9	36.8
1983	66.4	59.0	45.7	39.1	47.7	27.3	37.4
1984	NA	60.3	NA	41.1	47.3	26.6	39.3
1985	68.4	63.9	49.7	42.8	47.3	27.1	41.7
1986	NA	65.3	NA	43.7	48.2	28.4	43.7
1987	72.2	68.8	56.4	45.4	47.9	29.4	44.6
1988	NA	70.5	NA	47.6	48.5	30.9	45.4
1989	73.6	73.0	59.2	49.6	46.8	31.4	45.6
1990	NA	74.9	NA	49.9	46.7	31.8	46.4
1991	75.7	75.5	61.5	51.8	46.3	30.6	47.1
1992	NA	77.7	59.3	56.4	46.9	30.2	50.2
1993	74.3	79.6	58.0	57.9	49.2	32.6	52.0
1994	NA	81.4	NA	58.8	51.3	33.3	NA

NA = not available

[a] German data are for West Germany only before 1989.

SOURCE: Organisation for Economic Co-operation and Development, Main Statistics database (Paris: 1997).

See figure 3-13.

Science & Engineering Indicators – 1998

Appendix table 3-16.
Total science and engineering jobs: 1996 and projected 2006
(Thousands)

Occupation	1996	2006	Change
TOTAL, ALL OCCUPATIONS	132,353	150,927	18,574
ALL S&E OCCUPATIONS	3,060	4,421	1,361
Scientists	1,678	2,789	1,111
Life scientists	180	221	41
Agricultural and food	24	29	5
Biological	83	103	20
Foresters and conservation	37	43	6
Medical	35	44	9
All other	1	1	0
Computer, mathematical, and operations research	1,028	2,038	1,010
Actuaries	16	16	0
Computer systems analysts, engineers and scientists	933	1,937	1,004
Computer engineers and scientists	427	912	485
Computer engineers	216	451	235
Database administrators, computer support specialists, other	212	461	249
Systems analysts	506	1,025	519
Statisticians	14	14	0
Mathematicians	16	17	1
Operations research analysts	50	54	4
Physical scientists	207	242	35
Chemists	91	108	17
Geologists	47	54	7
Meterologists	7	8	1
Physicists and astronomers	18	17	–1
All other	43	55	12
Social scientists	263	288	25
Economists	51	60	9
Psychologists	143	154	11
Urban and regional planners	29	31	2
All other	41	43	2
Engineers	1,382	1,632	250
Aeronautical and astronautical	53	57	4
Chemical	49	57	8
Civil	196	231	35
Electrical and electronics	367	472	105
Industrial	115	131	16
Mechanical	228	264	36
Metallurgists	18	20	2
Mining	3	3	0
Nuclear	14	14	0
Petroleum	13	11	–2
All other	326	373	47

SOURCE: U.S. Bureau of Labor Statistics, Office of Employment Projections, "National Industry-Occupation Employment Projections 1996-2006" (Washington, DC: U.S. Department of Labor, 1997).

See figure 3-15.

Science & Engineering Indicators – 1998

Appendix table 4-1.

Gross domestic product and GDP implicit price deflators: 1960-99

	Gross domestic product (Billions of dollars)		GDP price deflator (1992 = 1.000)	
	Calendar year	Fiscal year	Calendar year	Fiscal year
1960	526.6	518.3	0.233	0.233
1961	544.8	530.4	0.236	0.237
1962	585.2	567.3	0.239	0.239
1963	617.4	599.0	0.242	0.242
1964	663.0	639.8	0.246	0.245
1965	719.1	686.8	0.250	0.249
1966	787.8	752.7	0.257	0.255
1967	833.6	811.9	0.266	0.263
1968	910.6	868.0	0.277	0.273
1969	982.2	948.1	0.290	0.285
1970	1,035.6	1,009.4	0.306	0.300
1971	1,125.4	1,077.4	0.321	0.316
1972	1,237.3	1,177.0	0.335	0.331
1973	1,382.6	1,306.8	0.354	0.345
1974	1,496.9	1,438.1	0.385	0.370
1975	1,630.6	1,554.5	0.422	0.408
1976	1,819.0	1,730.4	0.446	0.437
1977	2,026.9	1,971.4	0.475	0.470
1978	2,291.4	2,212.6	0.509	0.503
1979	2,557.5	2,495.9	0.553	0.545
1980	2,784.2	2,718.9	0.604	0.593
1981	3,115.9	3,049.1	0.661	0.652
1982	3,242.1	3,211.3	0.702	0.698
1983	3,514.5	3,421.9	0.732	0.730
1984	3,902.4	3,812.0	0.759	0.758
1985	4,180.7	4,102.1	0.786	0.784
1986	4,422.2	4,374.3	0.806	0.806
1987	4,692.3	4,605.1	0.831	0.829
1988	5,049.6	4,953.5	0.861	0.858
1989	5,438.7	5,351.8	0.897	0.894
1990	5,743.8	5,684.5	0.936	0.932
1991	5,916.7	5,858.8	0.973	0.972
1992	6,244.4	6,143.2	1.000	1.000
1993	6,553.0	6,470.8	1.026	1.026
1994	6,935.7	6,830.4	1.050	1.050
1995	7,253.8	7,186.9	1.076	1.076
1996	7,574.4	7,484.6	1.100	1.101
1997	7,957.7	7,859.8	1.129	1.129
1998	8,366.5	8,263.5	1.160	1.160
1999	8,790.2	8,681.4	1.191	1.191

NOTES: Data are projected for 1997-99 and are from the Mid-Session Review of the 1997 Budget, July 1996, updated for GDP revisions used in the President's 1998 budget.

SOURCES: U.S. Bureau of Economic Analysis, *Survey of Current Business* (Washington, DC: U.S. Department of Commerce, monthly series); and Office of Management and Budget, unpublished tabulations.

Science & Engineering Indicators – 1998

Appendix table 4-2.

Purchasing power parity and market exchange rates, by selected country: 1981-96

(Units of foreign currency per U.S. dollar)

	Purchasing power parities						Market exchange rates	
	Canada	France	Germany	Italy	Japan	United Kingdom	Germany	Japan
1981	1.26	5.62	2.37	878	238	0.519	2.26	221
1982	1.29	5.93	2.32	969	228	0.527	2.43	249
1983	1.30	6.26	2.30	1,073	223	0.534	2.55	238
1984	1.29	6.47	2.26	1,152	221	0.536	2.85	238
1985	1.28	6.62	2.23	1,213	218	0.549	2.94	239
1986	1.28	6.80	2.23	1,276	216	0.553	2.17	169
1987	1.30	6.79	2.20	1,314	210	0.563	1.80	145
1988	1.31	6.74	2.15	1,351	203	0.575	1.76	128
1989	1.32	6.68	2.10	1,376	199	0.590	1.88	138
1990	1.30	6.61	2.09	1,421	195	0.602	1.62	145
1991	1.29	6.53	2.10	1,467	194	0.637	1.66	135
1992	1.27	6.38	2.05	1,450	187	0.612	1.56	127
1993	1.26	6.57	2.10	1,534	184	0.637	1.65	111
1994	1.25	6.64	2.07	1,536	181	0.647	1.62	102
1995	1.23	6.62	2.07	1,589	176	0.670	1.43	94
1996	1.23	6.52	2.20	1,639	177	0.640	NA	NA

NA = not available

SOURCES: Organisation for Economic Co-operation and Development, Main Science and Technology Indicators database (Paris: August 1997); and International Monetary Fund, *International Financial Statistics Yearbook* (Washington, DC: 1996).

Science & Engineering Indicators – 1998

Appendix table 4-3.
U.S. R&D expenditures, by performing sector and source of funds: 1970-97
(Millions of current dollars)

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges						U&C FFRDCs	Other nonprofit institutions				Nonprofit FFRDCs
Funding sector:	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry[a]	Federal Govt.	Total	Federal Govt.	Nonfed. govt.	Industry	U&C	Non-profit	Federal Govt.[b]	Total	Federal Govt.	Industry	Non-profit	Federal Govt.
Calendar year[c]																		
1970	26,235	4,154	17,594	7,306	10,288	473	2,376	1,666	228	63	251	168	732	677	410	95	172	230
1971	26,910	4,409	17,829	7,175	10,654	491	2,533	1,742	259	71	282	180	725	709	427	98	184	215
1972	28,661	4,676	19,004	7,469	11,535	548	2,694	1,843	276	77	308	191	769	771	472	101	198	200
1973	30,905	4,837	20,704	7,600	13,104	545	2,919	1,997	298	87	331	206	829	882	566	105	211	190
1974	33,238	5,133	22,239	7,572	14,667	648	3,119	2,096	314	100	380	229	896	995	639	115	241	210
1975	35,565	5,561	23,460	7,878	15,582	727	3,489	2,344	340	116	424	266	1,027	1,076	675	125	276	225
1976	39,314	5,890	26,107	8,671	17,436	890	3,814	2,566	367	127	463	292	1,206	1,162	711	135	316	245
1977	43,233	6,211	28,863	9,523	19,340	962	4,207	2,809	384	147	541	325	1,467	1,248	740	150	358	275
1978	48,582	6,962	32,222	10,107	22,115	1,082	4,810	3,194	429	176	651	361	1,772	1,402	830	165	407	333
1979	55,269	7,471	37,062	11,354	25,708	1,164	5,540	3,723	477	204	760	377	2,013	1,629	985	180	464	390
1980	63,076	7,831	43,228	12,752	30,476	1,277	6,259	4,216	505	250	877	411	2,306	1,700	1,000	200	500	475
1981	72,190	8,605	50,425	14,997	35,428	1,385	6,966	4,620	564	303	1,031	449	2,484	1,788	1,038	225	525	538
1982	80,633	9,501	57,166	17,061	40,105	1,484	7,464	4,823	619	350	1,159	512	2,544	1,950	1,175	250	525	525
1983	89,742	10,830	63,683	19,095	44,588	1,585	8,067	5,100	642	411	1,329	585	2,840	2,138	1,313	275	550	600
1984	101,940	11,916	73,061	21,657	51,404	1,739	8,887	5,589	706	496	1,463	633	3,243	2,470	1,550	325	595	625
1985	114,344	13,093	82,376	25,333	57,043	1,863	9,997	6,226	793	595	1,680	704	3,616	2,736	1,700	375	661	663
1986	119,907	13,504	85,932	26,000	59,932	1,891	11,234	6,870	942	723	1,944	756	3,973	2,835	1,700	425	710	538
1987	125,841	13,588	90,160	28,757	61,403	1,995	12,481	7,556	1,044	811	2,215	855	4,287	2,828	1,569	456	803	501
1988	133,463	14,342	94,893	28,221	66,672	2,122	13,841	8,392	1,135	903	2,441	969	4,581	3,174	1,762	501	911	510
1989	141,550	15,231	99,860	26,359	73,501	2,195	15,303	9,152	1,248	1,028	2,774	1,101	4,756	3,658	2,062	562	1,035	547
1990	151,655	15,671	107,404	25,802	81,602	2,323	16,610	9,785	1,361	1,147	3,096	1,220	4,894	4,117	2,346	625	1,147	636
1991[d]	160,521	15,249	114,675	24,095	90,580	2,277	17,892	10,447	1,478	1,224	3,412	1,333	5,120	4,611	2,679	680	1,252	696
1992	164,932	15,853	116,757	22,369	94,388	2,353	19,099	11,306	1,508	1,300	3,558	1,428	5,259	4,864	2,806	716	1,342	748
1993	165,188	16,532	115,435	20,844	94,591	1,965	20,221	12,129	1,561	1,376	3,646	1,510	5,289	4,997	2,841	737	1,419	749
1994	168,554	16,440	117,392	20,261	97,131	2,202	21,305	12,826	1,588	1,437	3,867	1,585	5,305	5,152	2,899	764	1,489	759
1995	183,013	17,231	129,830	21,178	108,652	2,273	22,303	13,434	1,670	1,516	4,069	1,613	5,405	5,167	2,822	830	1,516	804
1996 prelim.	193,206	16,774	139,579	20,931	118,648	2,273	23,134	13,855	1,736	1,613	4,255	1,676	5,405	5,340	2,871	895	1,575	702
1997 prelim.	205,742	16,450	151,418	20,787	130,631	2,273	24,031	14,285	1,821	1,710	4,457	1,759	5,405	5,520	2,900	967	1,653	644

FFRDCs = federally funded research and development centers; U&C = universities and colleges

NOTES: Data are based on annual reports by performers except for the nonprofit sector; R&D expenditures by nonprofit sector performers have been estimated since 1973 on the basis of a survey conducted in that year. The next updates of these data, covering the years 1953-98, along with technical notes explaining methodological issues of measurement, will be provided in National Science Foundation, Science Resources Studies Division (NSF/SRS), *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming). Data are preliminary for 1996 and 1997.

[a] Industry sources of industry R&D expenditures include all nonfederal sources of industry R&D expenditures.

[b] Includes R&D expenditures of FFRDCs administered by academic institutions. In 1994, 99 percent of total funds used were from federal sources.

[c] Expenditure levels for academic and Federal Government performers are also in reference to calendar years, which represents a change from previous reporting in *National Patterns of R&D Resources*. These levels are approximations based on fiscal year data. For 1977 and later years, the calendar year approximation is equal to 75 percent of the amount reported in the same fiscal year plus 25 percent of the amount reported in the subsequent fiscal year. For years prior to 1977, the respective percentages are 50 and 50, since earlier fiscal years began on July 1 instead of October 1.

[d] Due to revisions in survey methodology and sampling of industrial R&D, data for 1991 and subsequent years may not be comparable to data for previous years. See NSF/SRS, *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>; or NSF/SRS, *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming).

SOURCE: NSF/SRS, *National Patterns of R&D Resources* (Arlington, VA: biennial series).

See figures 4-2, 4-6, and 4-7.

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Appendix table 4-4.
U.S. R&D expenditures, by performing sector and source of funds: 1970-97
(Millions of constant 1992 dollars)

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges						U&C FFRDCs	Other nonprofit institutions				Nonprofit FFRDCs
Funding sector:	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry[a]	Federal Govt.	Total	Federal Govt.	Nonfed. govt.	Industry	U&C	Non-profit	Federal Govt.[b]	Total	Federal Govt.	Industry	Non-profit	Federal Govt.
Calendar year[c]																		
1970	85,842	13,590	57,568	23,906	33,663	1,548	7,775	5,452	746	207	820	550	2,394	2,214	1,340	311	563	753
1971	83,719	13,715	55,468	22,322	33,146	1,528	7,879	5,419	804	221	877	558	2,256	2,204	1,327	305	572	669
1972	85,531	13,953	56,713	22,290	34,424	1,635	8,038	5,499	822	228	920	569	2,295	2,299	1,407	301	591	597
1973	87,361	13,672	58,526	21,483	37,042	1,541	8,250	5,644	843	245	934	583	2,343	2,493	1,600	297	596	537
1974	86,273	13,322	57,723	19,654	38,069	1,682	8,095	5,440	815	258	987	594	2,324	2,581	1,657	298	626	545
1975	84,358	13,191	55,645	18,686	36,959	1,724	8,276	5,560	806	274	1,006	630	2,436	2,552	1,601	296	655	534
1976	88,111	13,202	58,514	19,434	39,079	1,995	8,547	5,750	821	285	1,038	655	2,704	2,604	1,594	303	708	549
1977	91,091	13,087	60,813	20,064	40,748	2,027	8,863	5,919	809	309	1,140	685	3,091	2,630	1,560	316	754	579
1978	95,404	13,672	63,276	19,848	43,428	2,125	9,446	6,272	841	345	1,278	709	3,479	2,753	1,630	324	799	653
1979	100,009	13,519	67,064	20,545	46,519	2,106	10,025	6,737	863	369	1,375	682	3,642	2,948	1,782	326	840	706
1980	104,464	12,969	71,593	21,120	50,474	2,115	10,366	6,983	836	414	1,453	681	3,819	2,816	1,656	331	828	787
1981	109,294	13,027	76,343	22,705	53,637	2,097	10,547	6,995	853	458	1,561	680	3,761	2,706	1,571	341	795	814
1982	114,847	13,533	81,423	24,300	57,122	2,114	10,630	6,870	881	499	1,650	730	3,623	2,777	1,674	356	748	748
1983	122,613	14,796	87,009	26,089	60,920	2,166	11,021	6,967	877	561	1,816	800	3,881	2,920	1,793	376	751	820
1984	134,224	15,689	96,199	28,516	67,683	2,290	11,701	7,359	929	653	1,926	834	4,270	3,252	2,041	428	784	823
1985	145,559	16,667	104,864	32,249	72,615	2,372	12,726	7,926	1,009	757	2,139	896	4,603	3,483	2,164	477	842	843
1986	148,786	16,757	106,629	32,262	74,367	2,346	13,940	8,524	1,169	897	2,412	938	4,930	3,516	2,109	527	882	667
1987	151,499	16,359	108,543	34,620	73,923	2,402	15,025	9,096	1,257	976	2,667	1,029	5,161	3,405	1,889	548	967	604
1988	155,002	16,657	110,207	32,775	77,432	2,464	16,075	9,747	1,318	1,048	2,835	1,125	5,320	3,686	2,047	582	1,058	592
1989	157,761	16,975	111,297	29,378	81,919	2,446	17,056	10,200	1,391	1,146	3,092	1,227	5,300	4,077	2,298	626	1,153	610
1990	161,957	16,736	114,700	27,555	87,145	2,481	17,738	10,450	1,454	1,225	3,307	1,303	5,226	4,397	2,505	667	1,224	679
1991[d]	164,940	15,669	117,832	24,758	93,073	2,340	18,385	10,734	1,518	1,257	3,506	1,369	5,261	4,738	2,753	699	1,287	715
1992	164,932	15,853	116,757	22,369	94,388	2,353	19,099	11,306	1,508	1,300	3,558	1,428	5,259	4,864	2,806	716	1,342	748
1993	160,977	16,111	112,492	20,313	92,180	1,915	19,705	11,820	1,521	1,340	3,553	1,471	5,154	4,870	2,769	718	1,382	730
1994	160,592	15,663	111,847	19,304	92,543	2,098	20,298	12,220	1,513	1,369	3,685	1,510	5,054	4,909	2,762	728	1,419	724
1995	170,142	16,019	120,699	19,689	101,011	2,113	20,734	12,489	1,553	1,410	3,783	1,500	5,025	4,804	2,623	772	1,409	747
1996 prelim.	175,610	15,246	126,867	19,025	107,842	2,066	21,027	12,593	1,578	1,466	3,867	1,523	4,913	4,854	2,609	813	1,431	638
1997 prelim.	182,217	14,569	134,105	18,410	115,695	2,013	21,283	12,652	1,612	1,515	3,947	1,557	4,787	4,889	2,569	856	1,464	571

FFRDCs = federally funded research and development centers; U&C = universities and colleges

NOTES: Data are based on annual reports by performers except for the nonprofit sector; R&D expenditures by nonprofit sector performers have been estimated since 1973 on the basis of a survey conducted in that year. The next updates of these data, covering the years 1953-98, along with technical notes explaining methodological issues of measurement, will be provided in National Science Foundation, Science Resources Studies Division (NSF/SRS), *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming). Data are preliminary for 1996 and 1997.

[a] Industry sources of industry R&D expenditures include all nonfederal sources of industry R&D expenditures.

[b] Includes R&D expenditures of FFRDCs administered by academic institutions. In 1994, 99 percent of total funds used were from federal sources.

[c] Expenditure levels for academic and Federal Government performers are also in reference to calendar years, which represents a change from previous reporting in *National Patterns of R&D Resources*. These levels are approximations based on fiscal year data. For 1977 and later years, the calendar year approximation is equal to 75 percent of the amount reported in the same fiscal year plus 25 percent of the amount reported in the subsequent fiscal year. For years prior to 1977, the respective percentages are 50 and 50, since earlier fiscal years began on July 1 instead of October 1.

[d] Due to revisions in survey methodology and sampling of industrial R&D, data for 1991 and subsequent years may not be comparable to data for previous years. See NSF/SRS, *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>; or NSF/SRS, *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming).

SOURCE: NSF/SRS, *National Patterns of R&D Resources* (Arlington, VA: biennial series).

See figures 4-5, 4-6, 5-1, and 5-2.

Appendix table 4-5.

U.S. R&D expenditures, by source of funds and performer: 1970-97

(Millions of current dollars)

Funding sector:	Total U.S.	Federal Government								Industry				U&Cs	Nonprofit			Nonfed. govt.[a]
Performing sector:	Total U.S.	Total	Federal Govt.	Industry	Industry FFRDCs	U&Cs	U&C FFRDCs[b]	Non-profit	Nonprofit FFRDCs	Total	Industry[c]	U&Cs	Non-profit	U&Cs	Total	Non-profit	U&Cs	U&Cs[a]
Calendar year[d]																		
1970	26,235	14,970	4,154	7,306	473	1,666	732	410	230	10,446	10,288	63	95	251	340	172	168	228
1971	26,910	15,183	4,409	7,175	491	1,742	725	427	215	10,823	10,654	71	98	282	364	184	180	259
1972	28,661	15,976	4,676	7,469	548	1,843	769	472	200	11,713	11,535	77	101	308	389	198	191	276
1973	30,905	16,563	4,837	7,600	545	1,997	829	566	190	13,296	13,104	87	105	331	417	211	206	298
1974	33,238	17,193	5,133	7,572	648	2,096	896	639	210	14,882	14,667	100	115	380	470	241	229	314
1975	35,565	18,437	5,561	7,878	727	2,344	1,027	675	225	15,823	15,582	116	125	424	542	276	266	340
1976	39,314	20,179	5,890	8,671	890	2,566	1,206	711	245	17,698	17,436	127	135	463	608	316	292	367
1977	43,233	21,988	6,211	9,523	962	2,809	1,467	740	275	19,637	19,340	147	150	541	683	358	325	384
1978	48,582	24,279	6,962	10,107	1,082	3,194	1,772	830	333	22,456	22,115	176	165	651	768	407	361	429
1979	55,269	27,100	7,471	11,354	1,164	3,723	2,013	985	390	26,092	25,708	204	180	760	841	464	377	477
1980	63,076	29,857	7,831	12,752	1,277	4,216	2,306	1,000	475	30,926	30,476	250	200	877	911	500	411	505
1981	72,190	33,666	8,605	14,997	1,385	4,620	2,484	1,038	538	35,956	35,428	303	225	1,031	974	525	449	564
1982	80,633	37,113	9,501	17,061	1,484	4,823	2,544	1,175	525	40,705	40,105	350	250	1,159	1,037	525	512	619
1983	89,742	41,362	10,830	19,095	1,585	5,100	2,840	1,313	600	45,274	44,588	411	275	1,329	1,135	550	585	642
1984	101,940	46,319	11,916	21,657	1,739	5,589	3,243	1,550	625	52,225	51,404	496	325	1,463	1,228	595	633	706
1985	114,344	52,493	13,093	25,333	1,863	6,226	3,616	1,700	663	58,013	57,043	595	375	1,680	1,365	661	704	793
1986	119,907	54,475	13,504	26,000	1,891	6,870	3,973	1,700	538	61,079	59,932	723	425	1,944	1,466	710	756	942
1987	125,841	58,254	13,588	28,757	1,995	7,556	4,287	1,569	501	62,669	61,403	811	456	2,215	1,658	803	855	1,044
1988	133,463	59,930	14,342	28,221	2,122	8,392	4,581	1,762	510	68,076	66,672	903	501	2,441	1,880	911	969	1,135
1989	141,550	60,301	15,231	26,359	2,195	9,152	4,756	2,062	547	75,091	73,501	1,028	562	2,774	2,136	1,035	1,101	1,248
1990	151,655	61,456	15,671	25,802	2,323	9,785	4,894	2,346	636	83,374	81,602	1,147	625	3,096	2,367	1,147	1,220	1,361
1991[e]	160,521	60,563	15,249	24,095	2,277	10,447	5,120	2,679	696	92,484	90,580	1,224	680	3,412	2,585	1,252	1,333	1,478
1992	164,932	60,693	15,853	22,369	2,353	11,306	5,259	2,806	748	96,404	94,388	1,300	716	3,558	2,770	1,342	1,428	1,508
1993	165,188	60,350	16,532	20,844	1,965	12,129	5,289	2,841	749	96,704	94,591	1,376	737	3,646	2,928	1,419	1,510	1,561
1994	168,554	60,692	16,440	20,261	2,202	12,826	5,305	2,899	759	99,332	97,131	1,437	764	3,867	3,074	1,489	1,585	1,588
1995	183,013	63,147	17,231	21,178	2,273	13,434	5,405	2,822	804	110,998	108,652	1,516	830	4,069	3,129	1,516	1,613	1,670
1996 prelim.	193,206	62,810	16,774	20,931	2,273	13,855	5,405	2,871	702	121,156	118,648	1,613	895	4,255	3,250	1,575	1,676	1,736
1997 prelim.	205,742	62,745	16,450	20,787	2,273	14,285	5,405	2,900	644	133,308	130,631	1,710	967	4,457	3,411	1,653	1,759	1,821

FFRDCs = federally funded research and development centers; U&C = universities and colleges

NOTES: Data are based on annual reports by performers except for the nonprofit sector; R&D expenditures by nonprofit sector performers have been estimated since 1973 on the basis of a survey conducted in that year. The next updates of these data, covering the years 1953-98, along with technical notes explaining methodological issues of measurement, will be provided in National Science Foundation, Science Resources Studies Division (NSF/SRS), *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming). Data are preliminary for 1996 and 1997.

[a] Because of limitations in the survey information, data on nonfederal government funding to other performers are not available, and are consequently included in other sectors' support for their own R&D performance. For example, nonfederal government support to nonprofits is included in nonprofits' support for their own R&D (data column 16).

[b] Includes R&D expenditures of FFRDCs administered by academic institutions. In 1994, 99 percent of total funds used were from federal sources.

[c] Industry sources of industry R&D expenditures include all nonfederal sources of industry R&D expenditures.

[d] Expenditure levels for academic and Federal Government performers are also in reference to calendar years, which represents a change from previous reporting in *National Patterns of R&D Resources*. These levels are approximations based on fiscal year data. For 1977 and later years, the calendar year approximation is equal to 75 percent of the amount reported in the same fiscal year plus 25 percent of the amount reported in the subsequent fiscal year. For years prior to 1977, the respective percentages are 50 and 50, since earlier fiscal years began on July 1 instead of October 1.

[e] Due to revisions in survey methodology and sampling of industrial R&D, data for 1991 and subsequent years may not be comparable to data for previous years. See NSF/SRS, *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>; or NSF/SRS, *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming).

SOURCE: NSF/SRS, *National Patterns of R&D Resources* (Arlington, VA: biennial series).

See text table 4-1 and figures 4-1, 4-2, 4-3, 4-7, 4-8, 5-1, and 5-2.

Appendix table 4-6.

U.S. R&D expenditures, by source of funds and performer: 1970-97

(Millions of constant 1992 dollars)

Funding sector:	Total U.S.	Federal Government								Industry				U&Cs	Nonprofit			Nonfed. govt.[a]
Performing sector:	Total U.S.	Total	Federal Govt.	Industry	Industry FFRDCs	U&Cs	U&C FFRDCs[b]	Non-profit	Nonprofit FFRDCs	Total	Industry[c]	U&Cs	Non-profit	U&Cs	Total	Non-profit	U&Cs	U&Cs[a]
Calendar year[d]																		
1970	85,842	48,982	13,590	23,906	1,548	5,452	2,394	1,340	753	34,181	33,663	207	311	820	1,112	563	550	746
1971	83,719	47,236	13,715	22,322	1,528	5,419	2,256	1,327	669	33,671	33,146	221	305	877	1,131	572	558	804
1972	85,531	47,675	13,953	22,290	1,635	5,499	2,295	1,407	597	34,953	34,424	228	301	920	1,160	591	569	822
1973	87,361	46,821	13,672	21,483	1,541	5,644	2,343	1,600	537	37,584	37,042	245	297	934	1,179	596	583	843
1974	86,273	44,625	13,322	19,654	1,682	5,440	2,324	1,657	545	38,626	38,069	258	298	987	1,220	626	594	815
1975	84,358	43,732	13,191	18,686	1,724	5,560	2,436	1,601	534	37,530	36,959	274	296	1,006	1,284	655	630	806
1976	88,114	45,227	13,202	19,434	1,995	5,750	2,704	1,594	549	39,666	39,079	285	303	1,038	1,363	708	655	821
1977	91,091	46,328	13,087	20,064	2,027	5,919	3,091	1,560	579	41,374	40,748	309	316	1,140	1,440	754	685	809
1978	95,404	47,678	13,672	19,848	2,125	6,272	3,479	1,630	653	44,097	43,428	345	324	1,278	1,509	799	709	841
1979	100,009	49,037	13,519	20,545	2,106	6,737	3,642	1,782	706	47,213	46,519	369	326	1,375	1,521	840	682	863
1980	104,464	49,448	12,969	21,120	2,115	6,983	3,819	1,656	787	51,219	50,474	414	331	1,453	1,509	828	681	836
1981	109,294	50,970	13,027	22,705	2,097	6,995	3,761	1,571	814	54,436	53,637	458	341	1,561	1,475	795	680	853
1982	114,847	52,861	13,533	24,300	2,114	6,870	3,623	1,674	748	57,977	57,122	499	356	1,650	1,477	748	730	881
1983	122,613	56,512	14,796	26,089	2,166	6,967	3,881	1,793	820	61,857	60,920	561	376	1,816	1,551	751	800	877
1984	134,224	60,988	15,689	28,516	2,290	7,359	4,270	2,041	823	68,764	67,683	653	428	1,926	1,617	784	834	929
1985	145,559	66,824	16,667	32,249	2,372	7,926	4,603	2,164	843	73,850	72,615	757	477	2,139	1,737	842	896	1,009
1986	148,786	67,596	16,757	32,262	2,346	8,524	4,930	2,109	667	75,790	74,367	897	527	2,412	1,820	882	938	1,169
1987	151,499	70,131	16,359	34,620	2,402	9,096	5,161	1,889	604	75,447	73,923	976	548	2,667	1,996	967	1,029	1,257
1988	155,002	69,602	16,657	32,775	2,464	9,747	5,320	2,047	592	79,062	77,432	1,048	582	2,835	2,183	1,058	1,125	1,318
1989	157,761	67,207	16,975	29,378	2,446	10,200	5,300	2,298	610	83,691	81,919	1,146	626	3,092	2,380	1,153	1,227	1,391
1990	161,957	65,631	16,736	27,555	2,481	10,450	5,226	2,505	679	89,038	87,145	1,225	667	3,307	2,527	1,224	1,303	1,454
1991[e]	164,940	62,230	15,669	24,758	2,340	10,734	5,261	2,753	715	95,030	93,073	1,257	699	3,506	2,656	1,287	1,369	1,518
1992	164,932	60,693	15,853	22,369	2,353	11,306	5,259	2,806	748	96,404	94,388	1,300	716	3,558	2,770	1,342	1,428	1,508
1993	160,977	58,811	16,111	20,313	1,915	11,820	5,154	2,769	730	94,238	92,180	1,340	718	3,553	2,853	1,382	1,471	1,521
1994	160,592	57,825	15,663	19,304	2,098	12,220	5,054	2,762	724	94,640	92,543	1,369	728	3,685	2,929	1,419	1,510	1,513
1995	170,142	58,706	16,019	19,689	2,113	12,489	5,025	2,623	747	103,192	101,011	1,410	772	3,783	2,909	1,409	1,500	1,553
1996 prelim.	175,610	57,090	15,246	19,025	2,066	12,593	4,913	2,609	638	110,121	107,842	1,466	813	3,867	2,954	1,431	1,523	1,578
1997 prelim.	182,217	55,571	14,569	18,410	2,013	12,652	4,787	2,569	571	118,066	115,695	1,515	856	3,947	3,021	1,464	1,557	1,612

FFRDCs = federally funded research and development centers; U&C = universities and colleges

NOTES: Data are based on annual reports by performers except for the nonprofit sector; R&D expenditures by nonprofit sector performers have been estimated since 1973 on the basis of a survey conducted in that year. The next updates of these data, covering the years 1953-98, along with technical notes explaining methodological issues of measurement, will be provided in National Science Foundation, Science Resources Studies Division (NSF/SRS), *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming). Data are preliminary for 1996 and 1997.

[a] Because of limitations in the survey information, data on nonfederal government funding to other performers are not available, and are consequently included in other sectors' support for their own R&D performance. For example, nonfederal government support to nonprofits is included in nonprofits' support for their own R&D (data column 16).

[b] Includes R&D expenditures of FFRDCs administered by academic institutions. In 1994, 99 percent of total funds used were from federal sources.

[c] Industry sources of industry R&D expenditures include all nonfederal sources of industry R&D expenditures.

[d] Expenditure levels for academic and Federal Government performers are also in reference to calendar years, which represents a change from previous reporting in *National Patterns of R&D Resources*. These levels are approximations based on fiscal year data. For 1977 and later years, the calendar year approximation is equal to 75 percent of the amount reported in the same fiscal year plus 25 percent of the amount reported in the subsequent fiscal year. For years prior to 1977, the respective percentages are 50 and 50, since earlier fiscal years began on July 1 instead of October 1.

[e] Due to revisions in survey methodology and sampling of industrial R&D, data for 1991 and subsequent years may not be comparable to data for previous years. See NSF/SRS, *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>; or NSF/SRS, *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming).

SOURCE: NSF/SRS, *National Patterns of R&D Resources* (Arlington, VA: biennial series).

See figures 4-1, 4-4, 5-1, and 5-2.

Appendix table 4-7.

U.S. basic research expenditures, by performing sector and source of funds: 1970-97

(Millions of current dollars)

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges						U&C FFRDCs	Other nonprofit institutions				Nonprofit FFRDCs
Funding sector:	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry[a]	Federal Govt.[b]	Total	Federal Govt.	Nonfed. govt.	Industry	U&C	Non-profit	Federal Govt.[c]	Total	Federal Gov't	Industry	Non-profit	Federal Govt.
Calendar year[d]																		
1970	3,567	563	566	122	444	36	1,826	1,309	173	42	190	112	267	311	195	44	72	NA[b]
1971	3,698	582	557	101	456	33	1,941	1,367	193	48	211	123	256	329	207	45	77	NA[b]
1972	3,829	603	554	91	463	39	2,030	1,429	195	54	218	134	257	347	216	47	84	NA[b]
1973	4,051	652	595	96	499	36	2,078	1,471	196	58	217	135	320	371	232	49	90	NA[b]
1974	4,439	715	650	114	536	49	2,217	1,566	200	63	242	146	402	405	245	54	106	NA[b]
1975	4,827	760	677	104	573	53	2,445	1,732	212	72	265	165	457	435	255	60	120	NA[b]
1976	5,291	850	750	116	634	69	2,612	1,883	216	73	272	168	534	477	278	64	135	NA[b]
1977	5,925	943	836	135	701	75	2,883	2,061	227	84	320	192	667	521	301	70	150	NA[b]
1978	6,841	1,044	941	156	785	94	3,255	2,310	251	103	381	210	906	601	351	80	170	NA[b]
1979	7,736	1,112	1,054	161	893	104	3,723	2,648	282	121	450	223	1,050	693	413	85	195	NA[b]
1980	8,651	1,212	1,205	170	1,035	120	4,176	2,961	300	148	522	244	1,167	771	461	95	215	NA[b]
1981	9,741	1,343	1,477	164	1,313	137	4,665	3,296	329	177	602	262	1,284	835	505	105	225	NA[b]
1982	10,658	1,522	1,776	253	1,523	128	4,985	3,438	362	205	679	300	1,366	881	551	115	215	NA[b]
1983	11,859	1,733	2,106	346	1,760	117	5,411	3,618	388	248	803	354	1,536	958	613	125	220	NA[b]
1984	13,176	1,877	2,472	340	2,132	136	5,939	3,958	424	298	878	380	1,709	1,044	656	149	238	NA[b]
1985	14,510	1,947	2,731	358	2,373	131	6,790	4,474	487	366	1,032	432	1,793	1,118	681	172	264	NA[b]
1986	16,885	2,026	3,930	434	3,496	117	7,718	4,994	588	451	1,213	472	1,915	1,179	700	195	284	NA[b]
1987	18,213	2,047	4,181	598	3,583	142	8,518	5,451	650	505	1,380	532	2,086	1,238	707	210	321	NA[b]
1988	19,381	2,116	4,163	656	3,507	337	9,118	5,807	690	549	1,483	589	2,272	1,351	756	230	364	24
1989	21,477	2,309	4,818	986	3,832	398	10,003	6,307	750	618	1,667	661	2,371	1,532	860	258	414	46
1990	22,556	2,319	4,629	869	3,760	499	10,882	6,767	821	692	1,867	736	2,470	1,693	947	287	459	65
1991[e]	26,629	2,378	7,376	1,251	6,125	461	11,831	7,273	904	749	2,089	816	2,657	1,850	1,036	313	501	77
1992	27,044	2,419	6,528	712	5,816	474	12,710	7,886	933	805	2,202	884	2,867	1,980	1,114	329	537	67
1993	28,125	2,623	6,427	466	5,961	492	13,497	8,537	957	843	2,235	925	2,953	2,062	1,155	339	567	72
1994	28,934	2,557	6,514	436	6,078	503	14,267	9,091	970	878	2,361	968	2,944	2,075	1,128	351	596	74
1995	28,642	2,638	5,569	190	5,379	530	14,945	9,547	1,017	923	2,477	982	2,781	2,104	1,116	382	606	74
1996 prelim.	29,574	2,477	6,056	182	5,874	530	15,500	9,837	1,059	984	2,597	1,023	2,781	2,155	1,114	412	630	74
1997 prelim.	31,212	2,687	6,645	178	6,467	530	16,101	10,142	1,113	1,046	2,725	1,075	2,781	2,385	1,279	445	661	83

FFRDCs = federally funded research and development centers; U&C = universities and colleges

NOTES: Data are based on annual reports by performers except for the nonprofit sector; R&D expenditures by nonprofit sector performers have been estimated since 1973 on the basis of a survey conducted in that year. The next updates of these data, covering the years 1953-98, along with technical notes explaining methodological issues of measurement, will be provided in National Science Foundation, Science Resources Studies Division (NSF/SRS), *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming). Data are preliminary for 1996 and 1997.

[a] Industry sources of industry R&D expenditures include all nonfederal sources of industry R&D expenditures.

[b] For 1953-63, basic research of industry FFRDCs were not separated out from total federal support to the industrial sector for basic research. Thus, the figure for federal support to industry for basic research includes support for basic research at industry FFRDCs for those years. The same is true for basic research by nonprofit FFRDCs in 1953-87, which is included in federal support for basic research at nonprofit institutions for those years.

[c] Includes R&D expenditures of FFRDCs administered by academic institutions. In 1994, 99 percent of total funds used were from federal sources.

[d] Expenditure levels for academic and Federal Government performers are also in reference to calendar years, which represents a change from previous reporting in *National Patterns of R&D Resources*. These levels are approximations based on fiscal year data. For 1977 and later years, the calendar year approximation is equal to 75 percent of the amount reported in the same fiscal year plus 25 percent of the amount reported in the subsequent fiscal year. For years prior to 1977, the respective percentages are 50 and 50, since earlier fiscal years began on July 1 instead of October 1.

[e] Due to revisions in survey methodology and sampling of industrial R&D, data for 1991 and subsequent years may not be comparable to data for previous years. See NSF/SRS, *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>; or NSF/SRS, *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming).

SOURCE: NSF/SRS, *National Patterns of R&D Resources* (Arlington, VA: biennial series).

See figures 4-2 and 4-7.

Appendix table 4-8.
U.S. basic research expenditures, by performing sector and source of funds: 1970-97

(Millions of constant 1992 dollars)

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges						U&C FFRDCs	Other nonprofit institutions				Nonprofit FFRDCs
Funding sector:	**Total U.S.**	**Federal Govt.**	**Total**	**Federal Govt.**	**Industry[a]**	**Federal Govt.[b]**	**Total**	**Federal Govt.**	**Nonfed. govt.**	**Industry**	**U&C**	**Non-profit**	**Federal Govt.[c]**	**Total**	**Federal Gov't**	**Industry**	**Non-profit**	**Federal Govt.**
Calendar year[d]																		
1970	11,672	1,841	1,852	399	1,453	118	5,973	4,284	565	136	621	367	873	1016	636	144	236	NA[b]
1971	11,503	1,809	1,733	314	1,419	103	6,039	4,252	601	149	655	382	796	1024	644	140	240	NA[b]
1972	11,428	1,798	1,653	272	1,382	116	6,057	4,263	582	161	651	400	767	1036	645	140	251	NA[b]
1973	11,451	1,843	1,682	271	1,411	102	5,874	4,159	555	163	615	382	903	1047	654	139	254	NA[b]
1974	11,520	1,856	1,687	296	1,391	127	5,755	4,065	519	164	629	378	1044	1051	636	140	275	NA[b]
1975	11,449	1,803	1,606	247	1,359	126	5,799	4,107	503	170	628	391	1085	1032	605	142	285	NA[b]
1976	11,859	1,905	1,681	260	1,421	155	5,854	4,219	483	164	611	377	1197	1068	622	143	303	NA[b]
1977	12,484	1,987	1,761	284	1,477	158	6,075	4,341	478	177	673	405	1405	1098	635	147	316	NA[b]
1978	13,434	2,051	1,848	306	1,542	185	6,391	4,536	492	202	748	413	1779	1181	690	157	334	NA[b]
1979	13,998	2,013	1,907	291	1,616	188	6,737	4,792	510	219	813	404	1899	1253	746	154	353	NA[b]
1980	14,327	2,008	1,996	282	1,714	199	6,915	4,904	497	246	864	405	1932	1277	764	157	356	NA[b]
1981	14,748	2,033	2,236	248	1,988	207	7,063	4,989	498	267	911	397	1944	1264	765	159	341	NA[b]
1982	15,180	2,167	2,530	360	2,169	182	7,100	4,897	516	292	967	428	1946	1255	785	164	306	NA[b]
1983	16,203	2,367	2,877	473	2,405	160	7,392	4,943	530	339	1097	483	2098	1308	837	171	301	NA[b]
1984	17,349	2,471	3,255	448	2,807	179	7,819	5,212	558	393	1157	501	2250	1374	864	197	313	NA[b]
1985	18,472	2,479	3,477	456	3,021	167	8,644	5,695	620	465	1313	550	2282	1423	867	220	337	NA[b]
1986	20,952	2,514	4,877	539	4,338	145	9,577	6,197	730	560	1505	585	2377	1464	869	242	353	NA[b]
1987	21,926	2,465	5,033	720	4,314	171	10,255	6,562	783	608	1661	641	2511	1490	851	252	387	NA[b]
1988	22,508	2,458	4,835	762	4,073	391	10,590	6,744	801	637	1723	684	2638	1569	878	268	423	28
1989	23,937	2,573	5,370	1,099	4,271	444	11,148	7,030	836	688	1857	737	2643	1708	959	288	461	52
1990	24,088	2,476	4,943	928	4,015	533	11,621	7,226	877	739	1994	786	2638	1808	1011	307	490	69
1991[e]	27,362	2,444	7,579	1,285	6,294	474	12,156	7,473	929	770	2146	838	2730	1901	1064	322	515	79
1992	27,044	2,419	6,528	712	5,816	474	12,710	7,886	933	805	2202	884	2867	1980	1114	329	537	67
1993	27,408	2,556	6,263	454	5,809	479	13,152	8,319	932	822	2178	902	2878	2009	1126	330	553	70
1994	27,567	2,436	6,206	415	5,791	479	13,593	8,661	924	836	2250	922	2805	1977	1075	335	568	71
1995	26,628	2,453	5,177	177	5,001	493	13,894	8,875	945	858	2303	913	2585	1956	1038	355	564	69
1996 prelim.	26,881	2,252	5,505	166	5,339	482	14,088	8,941	963	895	2360	929	2528	1959	1013	374	572	68
1997 prelim.	27,643	2,379	5,885	158	5,728	469	14,260	8,983	986	926	2413	952	2463	2112	1133	394	585	74

FFRDCs = federally funded research and development centers; U&C = universities and colleges

NOTES: Data are based on annual reports by performers except for the nonprofit sector; R&D expenditures by nonprofit sector performers have been estimated since 1973 on the basis of a survey conducted in that year. The next updates of these data, covering the years 1953-98, along with technical notes explaining methodological issues of measurement, will be provided in National Science Foundation, Science Resources Studies Division (NSF/SRS), *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming). Data are preliminary for 1996 and 1997.

[a] Industry sources of industry R&D expenditures include all nonfederal sources of industry R&D expenditures.

[b] For 1953-63, basic research of industry FFRDCs were not separated out from total federal support to the industrial sector for basic research. Thus, the figure for federal support to industry for basic research includes support for basic research at industry FFRDCs for those years. The same is true for basic research by nonprofit FFRDCs in 1953-87, which is included in federal support for basic research at nonprofit institutions for those years.

[c] Includes R&D expenditures of FFRDCs administered by academic institutions. In 1994, 99 percent of total funds used were from federal sources.

[d] Expenditure levels for academic and Federal Government performers are also in reference to calendar years, which represents a change from previous reporting in *National Patterns of R&D Resources*. These levels are approximations based on fiscal year data. For 1977 and later years, the calendar year approximation is equal to 75 percent of the amount reported in the same fiscal year plus 25 percent of the amount reported in the subsequent fiscal year. For years prior to 1977, the respective percentages are 50 and 50, since earlier fiscal years began on July 1 instead of October 1.

[e] Due to revisions in survey methodology and sampling of industrial R&D, data for 1991 and subsequent years may not be comparable to data for previous years. See NSF/SRS, *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>; or NSF/SRS, *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming).

SOURCE: NSF/SRS, *National Patterns of R&D Resources* (Arlington, VA: biennial series).

Appendix table 4-9.

U.S. basic research expenditures, by source of funds and performer: 1970-97

(Millions of current dollars)

Funding sector:	Total U.S.	Federal Government								Industry				U&Cs	Nonprofit			Nonfed. govt.[a]
Performing sector:	Total U.S.	Total	Federal Govt.	Industry	Industry FFRDCs	U&Cs	U&C FFRDCs[b]	Non-profit	Nonprofit FFRDCs	Total	Industry[c]	U&Cs	Non-profit	U&Cs	Total	Non-profit	U&Cs	U&Cs[a]
Calendar year[d]																		
1970	3,567	2,491	563	122	36	1,309	267	195	NA[e]	530	444	42	44	190	184	72	112	173
1971	3,698	2,545	582	101	33	1,367	256	207	NA[e]	549	456	48	45	211	200	77	123	193
1972	3,829	2,634	603	91	39	1,429	257	216	NA[e]	564	463	54	47	218	218	84	134	195
1973	4,051	2,806	652	96	36	1,471	320	232	NA[e]	606	499	58	49	217	225	90	135	196
1974	4,439	3,091	715	114	49	1,566	402	245	NA[e]	653	536	63	54	242	252	106	146	200
1975	4,827	3,361	760	104	53	1,732	457	255	NA[e]	705	573	72	60	265	285	120	165	212
1976	5,291	3,729	850	116	69	1,883	534	278	NA[e]	771	634	73	64	272	303	135	168	216
1977	5,925	4,181	943	135	75	2,061	667	301	NA[e]	855	701	84	70	320	342	150	192	227
1978	6,841	4,861	1,044	156	94	2,310	906	351	NA[e]	968	785	103	80	381	380	170	210	251
1979	7,736	5,487	1,112	161	104	2,648	1,050	413	NA[e]	1,099	893	121	85	450	418	195	223	282
1980	8,651	6,091	1,212	170	120	2,961	1,167	461	NA[e]	1,278	1,035	148	95	522	459	215	244	300
1981	9,741	6,728	1,343	164	137	3,296	1,284	505	NA[e]	1,595	1,313	177	105	602	487	225	262	329
1982	10,658	7,258	1,522	253	128	3,438	1,366	551	NA[e]	1,843	1,523	205	115	679	515	215	300	362
1983	11,859	7,961	1,733	346	117	3,618	1,536	613	NA[e]	2,133	1,760	248	125	803	574	220	354	388
1984	13,176	8,676	1,877	340	136	3,958	1,709	656	NA[e]	2,579	2,132	298	149	878	618	238	380	424
1985	14,510	9,384	1,947	358	131	4,474	1,793	681	NA[e]	2,911	2,373	366	172	1,032	696	264	432	487
1986	16,885	10,186	2,026	434	117	4,994	1,915	700	NA[e]	4,142	3,496	451	195	1,213	756	284	472	588
1987	18,213	11,031	2,047	598	142	5,451	2,086	707	NA[e]	4,297	3,583	505	210	1,380	854	321	532	650
1988	19,381	11,968	2,116	656	337	5,807	2,272	756	24	4,286	3,507	549	230	1,483	953	364	589	690
1989	21,477	13,278	2,309	986	398	6,307	2,371	860	46	4,708	3,832	618	258	1,667	1,075	414	661	750
1990	22,556	13,935	2,319	869	499	6,767	2,470	947	65	4,739	3,760	692	287	1,867	1,194	459	736	821
1991[f]	26,629	15,133	2,378	1,251	461	7,273	2,657	1,036	77	7,187	6,125	749	313	2,089	1,317	501	816	904
1992	27,044	15,538	2,419	712	474	7,886	2,867	1,114	67	6,950	5,816	805	329	2,202	1,421	537	884	933
1993	28,125	16,297	2,623	466	492	8,537	2,953	1,155	72	7,143	5,961	843	339	2,235	1,493	567	925	957
1994	28,934	16,732	2,557	436	503	9,091	2,944	1,128	74	7,307	6,078	878	351	2,361	1,563	596	968	970
1995	28,642	16,876	2,638	190	530	9,547	2,781	1,116	74	6,684	5,379	923	382	2,477	1,588	606	982	1,017
1996 prelim.	29,574	16,996	2,477	182	530	9,837	2,781	1,114	74	7,270	5,874	984	412	2,597	1,652	630	1,023	1,059
1997 prelim.	31,212	17,680	2,687	178	530	10,142	2,781	1,279	83	7,957	6,467	1,046	445	2,725	1,736	661	1,075	1,113

FFRDCs = federally funded research and development centers; U&C = universities and colleges

NOTES: Data are based on annual reports by performers except for the nonprofit sector; R&D expenditures by nonprofit sector performers have been estimated since 1973 on the basis of a survey conducted in that year. The next updates of these data, covering the years 1953-98, along with technical notes explaining methodological issues of measurement, will be provided in National Science Foundation, Science Resources Studies Division (NSF/SRS), *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming). Data are preliminary for 1996 and 1997.

[a] Because of limitations in the survey information, data on nonfederal government funding to other performers are not available, and are consequently included in other sectors' support for their own R&D performance. For example, nonfederal government support to nonprofits is included in nonprofits' support for their own R&D (data column 16).

[b] Includes R&D expenditures of FFRDCs administered by academic institutions. In 1994, 99 percent of total funds used were from federal sources.

[c] Industry sources of industry R&D expenditures include all nonfederal sources of industry R&D expenditures.

[d] Expenditure levels for academic and Federal Government performers are also in reference to calendar years, which represents a change from previous reporting in *National Patterns of R&D Resources*. These levels are approximations based on fiscal year data. For 1977 and later years, the calendar year approximation is equal to 75 percent of the amount reported in the same fiscal year plus 25 percent of the amount reported in the subsequent fiscal year. For years prior to 1977, the respective percentages are 50 and 50, since earlier fiscal years began on July 1 instead of October 1.

[e] For 1953-63, basic research of industry FFRDCs were not separated out from total federal support to the industrial sector for basic research. Thus, the figure for federal support to industry for basic research includes support for basic research at industry FFRDCs for those years. The same is true for basic research by nonprofit FFRDCs in 1953–87, which is included in federal support for basic research at nonprofit institutions for those years.

[f] Due to revisions in survey methodology and sampling of industrial R&D, data for 1991 and subsequent years may not be comparable to data for previous years. See NSF/SRS, *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>; or NSF/SRS, *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming).

SOURCE: NSF/SRS, *National Patterns of R&D Resources* (Arlington, VA: biennial series).

See figures 4-7 and 4-8.

Science & Engineering Indicators – 1998

Appendix table 4-10.

U.S. basic research expenditures, by source of funds and performer: 1970-97

(Millions of constant 1992 dollars)

Funding sector:	Total U.S.	Federal Government								Industry				U&Cs	Nonprofit			Nonfed. govt.[a]
Performing sector:	Total U.S.	Total	Federal Govt.	Industry	Industry FFRDCs	U&Cs	U&C FFRDCs[b]	Non-profit	Nonprofit FFRDCs	Total	Industry[c]	U&Cs	Non-profit	U&Cs	Total	Non-profit	U&Cs	U&Cs[a]
Calendar year[d]																		
1970	11,672	8,151	1,841	399	118	4,284	873	636	NA[e]	1,733	1,453	136	144	621	603	236	367	565
1971	11,503	7,919	1,809	314	103	4,252	796	644	NA[e]	1,707	1,419	149	140	655	621	240	382	601
1972	11,428	7,861	1,798	272	116	4,263	767	645	NA[e]	1,683	1,382	161	140	651	651	251	400	582
1973	11,451	7,933	1,843	271	102	4,159	903	654	NA[e]	1,712	1,411	163	139	615	637	254	382	555
1974	11,520	8,024	1,856	296	127	4,065	1,044	636	NA[e]	1,695	1,391	164	140	629	653	275	378	519
1975	11,449	7,971	1,803	247	126	4,107	1,085	605	NA[e]	1,672	1,359	170	142	628	676	285	391	503
1976	11,859	8,358	1,905	260	155	4,219	1,197	622	NA[e]	1,728	1,421	164	143	611	680	303	377	483
1977	12,484	8,810	1,987	284	158	4,341	1,405	635	NA[e]	1,801	1,477	177	147	673	721	316	405	478
1978	13,434	9,546	2,051	306	185	4,536	1,779	690	NA[e]	1,900	1,542	202	157	748	747	334	413	492
1979	13,998	9,930	2,013	291	188	4,792	1,899	746	NA[e]	1,988	1,616	219	154	813	756	353	404	510
1980	14,327	10,087	2,008	282	199	4,904	1,932	764	NA[e]	2,117	1,714	246	157	864	761	356	405	497
1981	14,748	10,187	2,033	248	207	4,989	1,944	765	NA[e]	2,414	1,988	267	159	911	738	341	397	498
1982	15,180	10,338	2,167	360	182	4,897	1,946	785	NA[e]	2,625	2,169	292	164	967	734	306	428	516
1983	16,203	10,878	2,367	473	160	4,943	2,098	837	NA[e]	2,914	2,405	339	171	1,097	784	301	483	530
1984	17,349	11,424	2,471	448	179	5,212	2,250	864	NA[e]	3,396	2,807	393	197	1,157	814	313	501	558
1985	18,472	11,946	2,479	456	167	5,695	2,282	867	NA[e]	3,706	3,021	465	220	1,313	886	337	550	620
1986	20,952	12,639	2,514	539	145	6,197	2,377	869	NA[e]	5,140	4,338	560	242	1,505	938	353	585	730
1987	21,926	13,280	2,465	720	171	6,562	2,511	851	NA[e]	5,174	4,314	608	252	1,661	1,028	387	641	783
1988	22,508	13,899	2,458	762	391	6,744	2,638	878	28	4,978	4,073	637	268	1,723	1,107	423	684	801
1988	22,508	13,899	2,458	762	391	6,744	2,638	878	28	4,978	4,073	637	268	1,723	1,107	423	684	801
1989	23,937	14,798	2,573	1,099	444	7,030	2,643	959	52	5,247	4,271	688	288	1,857	1,198	461	737	836
1990	24,088	14,881	2,476	928	533	7,226	2,638	1,011	69	5,061	4,015	739	307	1,994	1,275	490	786	877
1991[f]	27,362	15,549	2,444	1,285	474	7,473	2,730	1,064	79	7,385	6,294	770	322	2,146	1,353	515	838	929
1992	27,044	15,538	2,419	712	474	7,886	2,867	1,114	67	6,950	5,816	805	329	2,202	1,421	537	884	933
1993	27,408	15,882	2,556	454	479	8,319	2,878	1,126	70	6,961	5,809	822	330	2,178	1,455	553	902	932
1994	27,567	15,942	2,436	415	479	8,661	2,805	1,075	71	6,962	5,791	836	335	2,250	1,490	568	922	924
1995	26,628	15,689	2,453	177	493	8,875	2,585	1,038	69	6,214	5,001	858	355	2,303	1,477	564	913	945
1996 prelim.	26,881	15,448	2,252	166	482	8,941	2,528	1,013	68	6,608	5,339	895	374	2,360	1,502	572	929	963
1997 prelim.	27,643	15,659	2,379	158	469	8,983	2,463	1,133	74	7,048	5,728	926	394	2,413	1,538	585	952	986

FFRDCs = federally funded research and development centers; U&C = universities and colleges

NOTES: Data are based on annual reports by performers except for the nonprofit sector; R&D expenditures by nonprofit sector performers have been estimated since 1973 on the basis of a survey conducted in that year. The next updates of these data, covering the years 1953-98, along with technical notes explaining methodological issues of measurement, will be provided in National Science Foundation, Science Resources Studies Division (NSF/SRS), *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming). Data are preliminary for 1996 and 1997.

[a] Because of limitations in the survey information, data on nonfederal government funding to other performers are not available, and are consequently included in other sectors' support for their own R&D performance. For example, nonfederal government support to nonprofits is included in nonprofits' support for their own R&D (data column 16).

[b] Includes R&D expenditures of FFRDCs administered by academic institutions. In 1994, 99 percent of total funds used were from federal sources.

[c] Industry sources of industry R&D expenditures include all nonfederal sources of industry R&D expenditures.

[d] Expenditure levels for academic and Federal Government performers are also in reference to calendar years, which represents a change from previous reporting in *National Patterns of R&D Resources*. These levels are approximations based on fiscal year data. For 1977 and later years, the calendar year approximation is equal to 75 percent of the amount reported in the same fiscal year plus 25 percent of the amount reported in the subsequent fiscal year. For years prior to 1977, the respective percentages are 50 and 50, since earlier fiscal years began on July 1 instead of October 1.

[e] For 1953-63, basic research of industry FFRDCs were not separated out from total federal support to the industrial sector for basic research. Thus, the figure for federal support to industry for basic research includes support for basic research at industry FFRDCs for those years. The same is true for basic research by nonprofit FFRDCs in 1953-87, which is included in federal support for basic research at nonprofit institutions for those years.

[f] Due to revisions in survey methodology and sampling of industrial R&D, data for 1991 and subsequent years may not be comparable to data for previous years. See NSF/SRS, *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>; or NSF/SRS, *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming).

SOURCE: NSF/SRS, *National Patterns of R&D Resources* (Arlington, VA: biennial series).

See figure 4-7.

Appendix table 4-11.
U.S. applied research expenditures, by performing sector and source of funds: 1970-97
(Millions of current dollars)

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges						U&C FFRDCs	Other nonprofit institutions				Nonprofit FFRDCs
Funding sector:	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry[a]	Federal Govt.[b]	Total	Federal Govt.	Nonfed. govt.	Industry	U&C	Non-profit	Federal Govt.[c]	Total	Federal Gov't	Industry	Non-profit	Federal Govt.
Calendar year[d]																		
1970	5,742	1,334	3,330	952	2,378	97	439	273	49	17	54	46	215	328	225	33	70	NA[b]
1971	5,817	1,355	3,348	907	2,441	67	487	299	58	19	63	48	213	349	241	34	74	NA[b]
1972	6,098	1,434	3,407	845	2,562	107	571	355	70	19	78	49	223	357	243	35	79	NA[b]
1973	6,662	1,527	3,715	883	2,832	110	719	455	85	25	95	59	215	376	257	36	83	NA[b]
1974	7,312	1,652	4,168	905	3,263	120	765	457	94	30	114	69	184	423	290	40	93	NA[b]
1975	8,048	1,912	4,431	991	3,440	139	892	532	107	36	133	85	211	463	315	43	105	NA[b]
1976	8,964	2,068	4,945	1,033	3,912	167	1,029	590	127	44	161	108	249	506	338	48	120	NA[b]
1977	9,653	2,081	5,424	1,113	4,311	212	1,096	616	131	49	185	116	297	543	355	53	135	NA[b]
1978	10,695	2,242	6,065	1,195	4,870	235	1,215	660	146	58	222	129	324	614	409	55	150	NA[b]
1979	12,073	2,415	6,975	1,305	5,670	250	1,363	750	161	68	257	127	360	710	480	60	170	NA[b]
1980	13,724	2,546	8,175	1,625	6,550	275	1,574	895	168	83	292	137	421	734	489	65	180	NA[b]
1981	16,389	2,731	10,401	2,042	8,359	298	1,750	950	192	103	352	153	422	786	521	75	190	NA[b]
1982	18,261	2,802	11,956	2,593	9,363	367	1,879	983	210	119	393	174	433	825	550	85	190	NA[b]
1983	20,323	2,991	13,513	3,227	10,286	414	2,051	1,088	208	133	431	190	473	880	585	95	200	NA[b]
1984	22,481	2,961	15,218	3,677	11,541	547	2,288	1,208	231	162	479	207	549	918	594	110	214	NA[b]
1985	25,389	3,135	17,625	4,717	12,908	630	2,473	1,280	251	188	532	223	579	947	581	127	238	NA[b]
1986	27,225	3,204	19,131	4,049	15,082	629	2,707	1,362	290	223	599	233	553	1,000	600	144	256	NA[b]
1987	27,819	3,366	19,190	4,037	15,153	623	3,072	1,549	323	251	685	264	532	1,037	593	155	289	NA[b]
1988	29,466	3,362	20,377	3,846	16,531	371	3,647	1,894	365	290	785	312	547	1,097	599	170	328	66
1989	32,304	3,566	22,317	4,324	17,993	374	4,116	2,102	409	337	908	360	602	1,258	695	191	372	70
1990	34,981	3,652	24,399	5,967	18,432	386	4,369	2,147	443	374	1,008	397	689	1,405	780	212	413	81
1991[e]	38,699	4,094	27,013	5,588	21,425	433	4,544	2,176	470	389	1,085	424	927	1,603	921	231	451	86
1992	37,995	4,337	25,660	4,476	21,184	507	4,810	2,375	471	406	1,111	446	940	1,660	933	243	483	81
1993	37,318	4,838	24,251	4,295	19,956	435	5,068	2,500	495	437	1,157	479	962	1,661	900	251	511	103
1994	36,615	5,006	22,988	3,616	19,372	503	5,272	2,565	507	459	1,235	506	981	1,753	957	260	536	112
1995	40,927	5,054	26,919	3,164	23,755	535	5,532	2,687	536	486	1,305	517	979	1,779	951	282	546	129
1996 prelim.	43,353	5,000	29,065	3,125	25,940	535	5,779	2,814	555	515	1,360	535	979	1,883	1,012	304	567	111
1997 prelim.	46,208	5,083	31,663	3,102	28,560	535	5,975	2,869	580	545	1,420	560	979	1,863	940	329	595	110

FFRDCs = federally funded research and development centers; U&C = universities and colleges

NOTES: Data are based on annual reports by performers except for the nonprofit sector; R&D expenditures by nonprofit sector performers have been estimated since 1973 on the basis of a survey conducted in that year. The next updates of these data, covering the years 1953-98, along with technical notes explaining methodological issues of measurement, will be provided in National Science Foundation, Science Resources Studies Division (NSF/SRS), *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming). Data are preliminary for 1996 and 1997.

[a] Industry sources of industry R&D expenditures include all nonfederal sources of industry R&D expenditures.

[b] For 1953-63, applied research of industry FFRDCs were not separated out from total federal support to the industrial sector for applied research. Thus, the figure for federal support to industry for applied research includes support for applied research at industry FFRDCs for those years. The same is true for applied research by nonprofit FFRDCs in 1953-87, which is included in federal support for applied research at nonprofit institutions for those years.

[c] Includes R&D expenditures of FFRDCs administered by academic institutions. In 1994, 99 percent of total funds used were from federal sources.

[d] Expenditure levels for academic and Federal Government performers are also in reference to calendar years, which represents a change from previous reporting in *National Patterns of R&D Resources*. These levels are approximations based on fiscal year data. For 1977 and later years, the calendar year approximation is equal to 75 percent of the amount reported in the same fiscal year plus 25 percent of the amount reported in the subsequent fiscal year. For years prior to 1977, the respective percentages are 50 and 50, since earlier fiscal years began on July 1 instead of October 1.

[e] Due to revisions in survey methodology and sampling of industrial R&D, data for 1991 and subsequent years may not be comparable to data for previous years. See NSF/SRS, *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>; or NSF/SRS, *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming).

SOURCE: NSF/SRS, *National Patterns of R&D Resources* (Arlington, VA: biennial series).

See figures 4-2 and 4-7.

Science & Engineering Indicators – 1998

Appendix table 4-12.

U.S. applied research expenditures, by performing sector and source of funds: 1970-97

(Millions of constant 1992 dollars)

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges						U&C FFRDCs	Other nonprofit institutions				Nonprofit FFRDCs
Funding sector:	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry[a]	Federal Govt.[b]	Total	Federal Govt.	Nonfed. govt.	Industry	U&C	Non-profit	Federal Govt.[c]	Total	Federal Gov't	Industry	Non-profit	Federal Govt.
Calendar year[d]																		
1970	18,787	4,363	10,896	3,115	7,781	317	1,436	894	161	55	177	150	702	1,073	736	108	229	NA[b]
1970	18,787	4,363	10,896	3,115	7,781	317	1,436	894	161	55	177	150	702	1,073	736	108	229	NA[b]
1971	18,098	4,214	10,416	2,822	7,594	208	1,514	930	180	58	197	148	662	1,084	748	106	230	NA[b]
1972	18,197	4,278	10,167	2,522	7,646	319	1,705	1,060	209	57	233	145	664	1,064	724	104	236	NA[b]
1973	18,831	4,316	10,501	2,496	8,005	311	2,032	1,287	241	69	267	167	607	1,063	726	102	235	NA[b]
1974	18,979	4,288	10,818	2,349	8,469	311	1,985	1,187	245	79	296	178	478	1,098	753	104	241	NA[b]
1975	19,089	4,534	10,510	2,351	8,159	330	2,117	1,262	253	86	315	200	500	1,098	747	102	249	NA[b]
1976	20,091	4,636	11,083	2,315	8,768	374	2,307	1,322	285	98	360	242	558	1,133	756	108	269	NA[b]
1977	20,339	4,384	11,428	2,345	9,083	447	2,310	1,298	276	102	389	244	626	1,144	748	112	284	NA[b]
1978	21,002	4,402	11,910	2,347	9,563	461	2,387	1,296	287	114	436	253	636	1,205	803	108	295	NA[b]
1979	21,847	4,370	12,621	2,361	10,260	452	2,467	1,357	292	123	465	230	651	1,285	869	109	308	NA[b]
1980	22,730	4,217	13,539	2,691	10,848	455	2,607	1,482	278	138	483	226	697	1,215	809	108	298	NA[b]
1981	24,812	4,135	15,747	3,092	12,655	451	2,649	1,438	291	156	532	232	639	1,190	789	114	288	NA[b]
1982	26,010	3,990	17,029	3,693	13,336	523	2,676	1,400	300	169	560	248	616	1,175	783	121	271	NA[b]
1983	27,767	4,087	18,463	4,409	14,054	566	2,803	1,487	285	182	589	259	647	1,202	799	130	273	NA[b]
1984	29,601	3,899	20,037	4,841	15,196	720	3,013	1,591	304	214	631	273	722	1,209	782	145	282	NA[b]
1985	32,320	3,991	22,437	6,005	16,432	802	3,148	1,629	319	240	677	283	738	1,205	740	162	303	NA[b]
1986	33,782	3,976	23,739	5,024	18,714	780	3,359	1,690	360	276	743	289	687	1,241	745	179	317	NA[b]
1987	33,491	4,052	23,103	4,860	18,243	750	3,698	1,864	389	302	825	318	640	1,248	714	186	348	NA[b]
1988	34,222	3,905	23,666	4,467	19,199	431	4,236	2,200	424	337	912	362	635	1,274	695	198	381	76
1989	36,004	3,975	24,873	4,819	20,054	417	4,587	2,343	455	375	1,012	402	671	1,402	774	213	415	78
1990	37,357	3,900	26,056	6,372	19,684	412	4,666	2,293	473	399	1,076	424	736	1,500	832	227	441	87
1991[e]	39,765	4,206	27,757	5,742	22,015	445	4,669	2,236	483	400	1,115	435	952	1,647	946	238	463	89
1992	37,995	4,337	25,660	4,476	21,184	507	4,810	2,375	471	406	1,111	446	940	1,660	933	243	483	81
1993	36,367	4,715	23,633	4,186	19,447	424	4,939	2,436	483	425	1,128	467	938	1,619	877	244	498	100
1994	34,886	4,770	21,902	3,445	18,457	479	5,023	2,444	483	437	1,177	482	935	1,670	912	247	511	106
1995	38,049	4,698	25,026	2,941	22,084	497	5,143	2,498	498	452	1,214	481	911	1,654	884	262	507	120
1996 prelim	39,404	4,545	26,418	2,840	23,578	486	5,253	2,557	504	469	1,236	487	890	1,711	919	276	515	101
1997 prelim	40,924	4,502	28,042	2,748	25,295	474	5,291	2,541	514	483	1,258	496	867	1,650	832	291	527	97

FFRDCs = federally funded research and development centers; U&C = universities and colleges

NOTES: Data are based on annual reports by performers except for the nonprofit sector; R&D expenditures by nonprofit sector performers have been estimated since 1973 on the basis of a survey conducted in that year. The next updates of these data, covering the years 1953-98, along with technical notes explaining methodological issues of measurement, will be provided in National Science Foundation, Science Resources Studies Division (NSF/SRS), *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming). Data are preliminary for 1996 and 1997.

[a] Industry sources of industry R&D expenditures include all nonfederal sources of industry R&D expenditures.

[b] For 1953-63, applied research of industry FFRDCs were not separated out from total federal support to the industrial sector for applied research. Thus, the figure for federal support to industry for applied research includes support for applied research at industry FFRDCs for those years. The same is true for applied research by nonprofit FFRDCs in 1953-87, which is included in federal support for applied research at nonprofit institutions for those years.

[c] Includes R&D expenditures of FFRDCs administered by academic institutions. In 1994, 99 percent of total funds used were from federal sources.

[d] Expenditure levels for academic and Federal Government performers are also in reference to calendar years, which represents a change from previous reporting in *National Patterns of R&D Resources*. These levels are approximations based on fiscal year data. For 1977 and later years, the calendar year approximation is equal to 75 percent of the amount reported in the same fiscal year plus 25 percent of the amount reported in the subsequent fiscal year. For years prior to 1977, the respective percentages are 50 and 50, since earlier fiscal years began on July 1 instead of October 1.

[e] Due to revisions in survey methodology and sampling of industrial R&D, data for 1991 and subsequent years may not be comparable to data for previous years. See NSF/SRS, *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>, or NSF/SRS, *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming).

SOURCE: NSF/SRS, *National Patterns of R&D Resources* (Arlington, VA: biennial series).

See figure 4-7.

Appendix table 4-13.

U.S. applied research expenditures, by source of funds and performer: 1970-97

(Millions of current dollars)

Funding sector:	Total U.S.	Federal Government								Industry				U&Cs	Nonprofit			Nonfed. govt.[a]
Performing sector:	Total U.S.	Total	Federal Govt.	Industry	Industry FFRDCs	U&Cs	U&C FFRDCs[b]	Non-profit	Nonprofit FFRDCs	Total	Industry[c]	U&Cs	Non-profit	U&Cs	Total	Non-profit	U&Cs	U&Cs[a]
Calendar year[d]																		
1970	5,742	3,095	1,334	952	97	273	215	225	NA[e]	2,428	2,378	17	33	54	116	70	46	49
1971	5,817	3,081	1,355	907	67	299	213	241	NA[e]	2,494	2,441	19	34	63	122	74	48	58
1972	6,098	3,206	1,434	845	107	355	223	243	NA[e]	2,616	2,562	19	35	78	128	79	49	70
1973	6,662	3,447	1,527	883	110	455	215	257	NA[e]	2,893	2,832	25	36	95	142	83	59	85
1974	7,312	3,609	1,652	905	120	457	184	290	NA[e]	3,333	3,263	30	40	114	162	93	69	94
1975	8,048	4,100	1,912	991	139	532	211	315	NA[e]	3,519	3,440	36	43	133	190	105	85	107
1976	8,964	4,444	2,068	1,033	167	590	249	338	NA[e]	4,004	3,912	44	48	161	228	120	108	127
1977	9,653	4,674	2,081	1,113	212	616	297	355	NA[e]	4,413	4,311	49	53	185	251	135	116	131
1978	10,695	5,064	2,242	1,195	235	660	324	409	NA[e]	4,983	4,870	58	55	222	279	150	129	146
1979	12,073	5,560	2,415	1,305	250	750	360	480	NA[e]	5,798	5,670	68	60	257	297	170	127	161
1980	13,724	6,251	2,546	1,625	275	895	421	489	NA[e]	6,698	6,550	83	65	292	317	180	137	168
1981	16,389	6,964	2,731	2,042	298	950	422	521	NA[e]	8,537	8,359	103	75	352	343	190	153	192
1982	18,261	7,727	2,802	2,593	367	983	433	550	NA[e]	9,567	9,363	119	85	393	364	190	174	210
1983	20,323	8,779	2,991	3,227	414	1,088	473	585	NA[e]	10,514	10,286	133	95	431	390	200	190	208
1984	22,481	9,536	2,961	3,677	547	1,208	549	594	NA[e]	11,814	11,541	162	110	479	422	214	207	231
1985	25,389	10,922	3,135	4,717	630	1,280	579	581	NA[e]	13,224	12,908	188	127	532	461	238	223	251
1986	27,225	10,398	3,204	4,049	629	1,362	553	600	NA[e]	15,449	15,082	223	144	599	489	256	233	290
1987	27,819	10,699	3,366	4,037	623	1,549	532	593	NA[e]	15,559	15,153	251	155	685	554	289	264	323
1988	29,466	10,684	3,362	3,846	371	1,894	547	599	66	16,992	16,531	290	170	785	640	328	312	365
1988	29,466	10,684	3,362	3,846	371	1,894	547	599	66	16,992	16,531	290	170	785	640	328	312	365
1989	32,304	11,733	3,566	4,324	374	2,102	602	695	70	18,521	17,993	337	191	908	733	372	360	409
1990	34,981	13,702	3,652	5,967	386	2,147	689	780	81	19,018	18,432	374	212	1,008	810	413	397	443
1991[f]	38,699	14,224	4,094	5,588	433	2,176	927	921	86	22,045	21,425	389	231	1,085	875	451	424	470
1992	37,995	13,650	4,337	4,476	507	2,375	940	933	81	21,834	21,184	406	243	1,111	929	483	446	471
1993	37,318	14,033	4,838	4,295	435	2,500	962	900	103	20,643	19,956	437	251	1,157	990	511	479	495
1994	36,615	13,741	5,006	3,616	503	2,565	981	957	112	20,091	19,372	459	260	1,235	1,042	536	506	507
1995	40,927	13,499	5,054	3,164	535	2,687	979	951	129	24,524	23,755	486	282	1,305	1,063	546	517	536
1996 prelim.	43,353	13,576	5,000	3,125	535	2,814	979	1,012	111	26,760	25,940	515	304	1,360	1,102	567	535	555
1997 prelim.	46,208	13,618	5,083	3,102	535	2,869	979	940	110	29,434	28,560	545	329	1,420	1,155	595	560	580

FFRDCs = federally funded research and development centers; U&C = universities and colleges

NOTES: Data are based on annual reports by performers except for the nonprofit sector; R&D expenditures by nonprofit sector performers have been estimated since 1973 on the basis of a survey conducted in that year. The next updates of these data, covering the years 1953-98, along with technical notes explaining methodological issues of measurement, will be provided in National Science Foundation, Science Resources Studies Division (NSF/SRS), *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming). Data are preliminary for 1996 and 1997.

[a] Because of limitations in the survey information, data on nonfederal government funding to other performers are not available, and are consequently included in other sectors' support for their own R&D performance. For example, nonfederal government support to nonprofits is included in nonprofits' support for their own R&D (data column 16).

[b] Includes R&D expenditures of FFRDCs administered by academic institutions. In 1994, 99 percent of total funds used were from federal sources.

[c] Industry sources of industry R&D expenditures include all nonfederal sources of industry R&D expenditures.

[d] Expenditure levels for academic and Federal Government performers are also in reference to calendar years, which represents a change from previous reporting in *National Patterns of R&D Resources*. These levels are approximations based on fiscal year data. For 1977 and later years, the calendar year approximation is equal to 75 percent of the amount reported in the same fiscal year plus 25 percent of the amount reported in the subsequent fiscal year. For years prior to 1977, the respective percentages are 50 and 50, since earlier fiscal years began on July 1 instead of October 1.

[e] For 1953-63, applied research of industry FFRDCs were not separated out from total federal support to the industrial sector for applied research. Thus, the figure for federal support to industry for applied research includes support for applied research at industry FFRDCs for those years. The same is true for applied research by nonprofit FFRDCs in 1953-87, which is included in federal support for applied research at nonprofit institutions for those years.

[f] Due to revisions in survey methodology and sampling of industrial R&D, data for 1991 and subsequent years may not be comparable to data for previous years. See NSF/SRS, *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>; or NSF/SRS, *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming).

SOURCE: NSF/SRS, *National Patterns of R&D Resources* (Arlington, VA: biennial series).

See figures 4-7 and 4-8.

Science & Engineering Indicators – 1998

Appendix table 4-14.

U.S. applied research expenditures, by source of funds and performer: 1970-97

(Millions of constant 1992 dollars)

Funding sector:	Total U.S.	Federal Government								Industry				U&Cs	Nonprofit			Nonfed. govt.[a]
Performing sector:	Total U.S.	Total	Federal Govt.	Industry	Industry FFRDCs	U&Cs	U&C FFRDCs[b]	Non-profit	Nonprofit FFRDCs	Total	Industry[c]	U&Cs	Non-profit	U&Cs	Total	Non-profit	U&Cs	U&Cs[a]
Calendar year[d]																		
1970	18,787	10,128	4,363	3,115	317	894	702	736	NA[e]	7,944	7,781	55	108	177	379	229	150	161
1971	18,098	9,585	4,214	2,822	208	930	662	748	NA[e]	7,758	7,594	58	106	197	378	230	148	180
1972	18,197	9,567	4,278	2,522	319	1,060	664	724	NA[e]	7,808	7,646	57	104	233	381	236	145	209
1973	18,831	9,744	4,316	2,496	311	1,287	607	726	NA[e]	8,176	8,005	69	102	267	402	235	167	241
1974	18,979	9,366	4,288	2,349	311	1,187	478	753	NA[e]	8,652	8,469	79	104	296	420	241	178	245
1975	19,089	9,724	4,534	2,351	330	1,262	500	747	NA[e]	8,347	8,159	86	102	315	449	249	200	253
1976	20,091	9,961	4,636	2,315	374	1,322	558	756	NA[e]	8,974	8,768	98	108	360	511	269	242	285
1977	20,339	9,848	4,384	2,345	447	1,298	626	748	NA[e]	9,297	9,083	102	112	389	528	284	244	276
1978	21,002	9,945	4,402	2,347	461	1,296	636	803	NA[e]	9,786	9,563	114	108	436	547	295	253	287
1979	21,847	10,061	4,370	2,361	452	1,357	651	869	NA[e]	10,492	10,260	123	109	465	537	308	230	292
1980	22,730	10,352	4,217	2,691	455	1,482	697	809	NA[e]	11,093	10,848	138	108	483	524	298	226	278
1981	24,812	10,544	4,135	3,092	451	1,438	639	789	NA[e]	12,925	12,655	156	114	532	520	288	232	291
1982	26,010	11,006	3,990	3,693	523	1,400	616	783	NA[e]	13,626	13,336	169	121	560	518	271	248	300
1983	27,767	11,994	4,087	4,409	566	1,487	647	799	NA[e]	14,366	14,054	182	130	589	533	273	259	285
1984	29,601	12,555	3,899	4,841	720	1,591	722	782	NA[e]	15,555	15,196	214	145	631	555	282	273	304
1985	32,320	13,904	3,991	6,005	802	1,629	738	740	NA[e]	16,834	16,432	240	162	677	586	303	283	319
1986	33,782	12,902	3,976	5,024	780	1,690	687	745	NA[e]	19,170	18,714	276	179	743	607	317	289	360
1987	33,491	12,880	4,052	4,860	750	1,864	640	714	NA[e]	18,731	18,243	302	186	825	666	348	318	389
1988	34,222	12,409	3,905	4,467	431	2,200	635	695	76	19,734	19,199	337	198	912	743	381	362	424
1989	36,004	13,077	3,975	4,819	417	2,343	671	774	78	20,642	20,054	375	213	1,012	817	415	402	455
1990	37,357	14,633	3,900	6,372	412	2,293	736	832	87	20,310	19,684	399	227	1,076	865	441	424	473
1991[f]	39,765	14,616	4,206	5,742	445	2,236	952	946	89	22,652	22,015	400	238	1,115	899	463	435	483
1992	37,995	13,650	4,337	4,476	507	2,375	940	933	81	21,834	21,184	406	243	1,111	929	483	446	471
1993	36,367	13,675	4,715	4,186	424	2,436	938	877	100	20,117	19,447	425	244	1,128	965	498	467	483
1994	34,886	13,091	4,770	3,445	479	2,444	935	912	106	19,142	18,457	437	247	1,177	993	511	482	483
1995	38,049	12,550	4,698	2,941	497	2,498	911	884	120	22,799	22,084	452	262	1,214	988	507	481	498
1996 prelim.	39,404	12,339	4,545	2,840	486	2,557	890	919	101	24,323	23,578	469	276	1,236	1,002	515	487	504
1997 prelim.	40,924	12,061	4,502	2,748	474	2,541	867	832	97	26,069	25,295	483	291	1,258	1,023	527	496	514

FFRDCs = federally funded research and development centers; U&C = universities and colleges

NOTES: Data are based on annual reports by performers except for the nonprofit sector; R&D expenditures by nonprofit sector performers have been estimated since 1973 on the basis of a survey conducted in that year. The next updates of these data, covering the years 1953-98, along with technical notes explaining methodological issues of measurement, will be provided in National Science Foundation, Science Resources Studies Division (NSF/SRS), *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming). Data are preliminary for 1996 and 1997.

[a] Because of limitations in the survey information, data on nonfederal government funding to other performers are not available, and are consequently included in other sectors' support for their own R&D performance. For example, nonfederal government support to nonprofits is included in nonprofits' support for their own R&D (data column 16).

[b] Includes R&D expenditures of FFRDCs administered by academic institutions. In 1994, 99 percent of total funds used were from federal sources.

[c] Industry sources of industry R&D expenditures include all nonfederal sources of industry R&D expenditures.

[d] Expenditure levels for academic and Federal Government performers are also in reference to calendar years, which represents a change from previous reporting in *National Patterns of R&D Resources*. These levels are approximations based on fiscal year data. For 1977 and later years, the calendar year approximation is equal to 75 percent of the amount reported in the same fiscal year plus 25 percent of the amount reported in the subsequent fiscal year. For years prior to 1977, the respective percentages are 50 and 50, since earlier fiscal years began on July 1 instead of October 1.

[e] For 1953-63, applied research of industry FFRDCs were not separated out from total federal support to the industrial sector for applied research. Thus, the figure for federal support to industry for applied research includes support for applied research at industry FFRDCs for those years. The same is true for applied research by nonprofit FFRDCs in 1953-87, which is included in federal support for applied research at nonprofit institutions for those years.

[f] Due to revisions in survey methodology and sampling of industrial R&D, data for 1991 and subsequent years may not be comparable to data for previous years. See NSF/SRS, *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>; or NSF/SRS, *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming).

SOURCE: NSF/SRS, *National Patterns of R&D Resources* (Arlington, VA: biennial series).

See figure 4-7.

Appendix table 4-15.

U.S. development expenditures, by performing sector and source of funds: 1970-97

(Millions of current dollars)

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges						U&C FFRDCs	Other nonprofit institutions				Nonprofit FFRDCs
Funding sector:	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry[a]	Federal Govt.[b]	Total	Federal Govt.	Nonfed. govt.	Industry	U&C	Non-profit	Federal Govt.[c]	Total	Federal Gov't	Industry	Non-profit	Federal Govt.
Calendar year[d]																		
1970	16,926	2,258	13,698	6,232	7,466	340	112	84	6	5	7	10	251	268	220	18	30	NA[b]
1971	17,395	2,473	13,924	6,167	7,757	391	105	76	7	5	8	9	257	246	194	19	33	NA[b]
1972	18,734	2,640	15,043	6,533	8,510	402	93	59	11	3	12	8	290	267	213	19	35	NA[b]
1973	20,193	2,658	16,394	6,621	9,773	399	122	70	17	5	19	12	295	326	268	20	38	NA[b]
1974	21,488	2,766	17,421	6,553	10,868	479	137	73	20	6	24	15	309	377	314	21	42	NA[b]
1975	22,691	2,890	18,352	6,783	11,569	535	152	80	21	8	27	16	359	403	330	22	51	NA[b]
1976	25,059	2,972	20,412	7,522	12,890	654	173	93	24	10	30	16	424	425	341	23	61	NA[b]
1977	27,655	3,188	22,603	8,275	14,328	675	227	133	26	14	37	17	503	459	359	27	73	NA[b]
1978	31,047	3,676	25,216	8,756	16,460	753	340	224	32	15	48	22	542	520	403	30	87	NA[b]
1979	35,460	3,944	29,033	9,888	19,145	810	454	325	34	15	53	27	603	617	483	35	99	NA[b]
1980	40,701	4,072	33,848	10,957	22,891	882	510	361	37	18	64	30	719	670	525	40	105	NA[b]
1981	46,060	4,530	38,547	12,791	25,756	950	551	375	42	23	77	34	778	704	549	45	110	NA[b]
1982	51,714	5,178	43,434	14,215	29,219	989	599	402	46	26	86	38	745	769	599	50	120	NA[b]
1983	57,560	6,106	48,064	15,522	32,542	1,054	605	393	46	29	95	42	832	900	715	55	130	NA[b]
1984	66,284	7,078	55,371	17,640	37,731	1,056	660	423	51	36	105	46	987	1,133	925	65	143	NA[b]
1985	74,444	8,011	62,020	20,258	41,762	1,102	734	472	55	41	117	49	1,244	1,334	1,100	75	159	NA[b]
1986	75,796	8,275	62,871	21,517	41,354	1,145	809	513	64	49	132	51	1,503	1,193	938	85	171	NA[b]
1987	79,809	8,176	66,789	24,122	42,667	1,230	890	556	71	55	150	58	1,669	1,055	771	91	193	NA[b]
1988	84,614	8,864	70,353	23,719	46,634	1,414	1,076	691	80	64	172	68	1,761	726	407	100	219	420
1989	87,767	9,355	72,725	21,049	51,676	1,423	1,185	742	90	74	199	79	1,781	868	507	112	248	430
1990	94,118	9,700	78,376	18,966	59,410	1,438	1,359	871	97	82	221	87	1,735	1,019	619	125	275	490
1991[e]	95,193	8,778	80,286	17,256	63,030	1,383	1,518	998	103	85	238	93	1,537	1,159	722	136	301	533
1992	99,894	9,098	84,569	17,181	67,388	1,373	1,580	1,045	103	89	244	98	1,452	1,223	758	143	322	599
1993	99,746	9,071	84,757	16,083	68,674	1,039	1,656	1,092	109	96	254	105	1,374	1,275	787	147	340	574
1994	103,005	8,877	87,890	16,209	71,681	1,196	1,765	1,171	111	101	271	111	1,380	1,324	814	153	357	574
1995	113,445	9,539	97,342	17,824	79,518	1,209	1,826	1,201	118	107	287	114	1,645	1,284	754	166	364	600
1996 prelim.	120,281	9,297	104,457	17,624	86,834	1,209	1,855	1,204	122	113	298	118	1,645	1,302	745	179	378	516
1997 prelim.	128,323	8,681	113,111	17,507	95,604	1,209	1,956	1,274	127	120	312	123	1,645	1,272	682	193	397	451

FFRDCs = federally funded research and development centers; U&C = universities and colleges

NOTES: Data are based on annual reports by performers except for the nonprofit sector; R&D expenditures by nonprofit sector performers have been estimated since 1973 on the basis of a survey conducted in that year. The next updates of these data, covering the years 1953-98, along with technical notes explaining methodological issues of measurement, will be provided in National Science Foundation, Science Resources Studies Division (NSF/SRS), *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming). Data are preliminary for 1996 and 1997.

[a] Industry sources of industry R&D expenditures include all nonfederal sources of industry R&D expenditures.

[b] For 1953-63, development expenditures by industry FFRDCs were not separated out from total federal support to the industrial sector for development. Thus, the figure for federal support to industry for development includes support for development at industry FFRDCs for those years. The same is true for development by nonprofit FFRDCs in 1953-87, which is included in federal support for development at nonprofit institutions for those years.

[c] Includes R&D expenditures of FFRDCs administered by academic institutions. In 1994, 99 percent of total funds used were from federal sources.

[d] Expenditure levels for academic and Federal Government performers are also in reference to calendar years, which represents a change from previous reporting in *National Patterns of R&D Resources*. These levels are approximations based on fiscal year data. For 1977 and later years, the calendar year approximation is equal to 75 percent of the amount reported in the same fiscal year plus 25 percent of the amount reported in the subsequent fiscal year. For years prior to 1977, the respective percentages are 50 and 50, since earlier fiscal years began on July 1 instead of October 1.

[e] Due to revisions in survey methodology and sampling of industrial R&D, data for 1991 and subsequent years may not be comparable to data for previous years. See NSF/SRS, *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>; or NSF/SRS, *National Patterns of R&D Resources:1998* (Arlington, VA: forthcoming).

SOURCE: NSF/SRS, *National Patterns of R&D Resources* (Arlington, VA: biennial series).

See figures 4-2 and 4-7.

Science & Engineering Indicators – 1998

Appendix table 4-16.

U.S. development expenditures, by performing sector and source of funds: 1970-97

(Millions of constant 1992 dollars)

Performing sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs	Universities & colleges						U&C FFRDCs	Other nonprofit institutions				Nonprofit FFRDCs
Funding sector:	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry[a]	Federal Govt.[b]	Total	Federal Govt.	Nonfed. govt.	Industry	U&C	Non-profit	Federal Govt.[c]	Total	Federal Gov't	Industry	Non-profit	Federal Govt.
Calendar year[d]																		
1970	55,383	7,387	44,820	20,391	24,429	1,112	366	274	21	16	23	33	820	877	720	59	98	NA[b]
1971	54,118	7,692	43,319	19,186	24,133	1,216	327	236	23	14	25	29	798	765	604	59	103	NA[b]
1972	55,906	7,877	44,892	19,496	25,396	1,200	276	175	32	10	35	24	864	797	636	57	104	NA[b]
1973	57,080	7,512	46,342	18,716	27,626	1,128	344	199	47	13	52	33	833	920	756	57	107	NA[b]
1974	55,773	7,178	45,218	17,009	28,209	1,243	355	189	51	16	61	38	802	977	814	55	109	NA[b]
1975	53,820	6,854	43,529	16,089	27,441	1,269	361	190	51	18	64	38	851	956	783	52	121	NA[b]
1976	56,166	6,661	45,749	16,859	28,890	1,466	388	209	53	23	67	36	949	953	764	52	137	NA[b]
1977	58,268	6,717	47,623	17,435	30,188	1,422	478	279	55	30	78	36	1,060	967	756	57	154	NA[b]
1978	60,968	7,219	49,518	17,195	32,323	1,479	668	440	62	29	94	44	1,064	1,020	790	59	171	NA[b]
1979	64,165	7,136	52,535	17,892	34,643	1,466	821	588	61	27	97	48	1,092	1,116	873	63	179	NA[b]
1980	67,408	6,745	56,058	18,147	37,912	1,461	844	597	61	30	106	50	1,190	1,110	869	66	174	NA[b]
1981	69,734	6,859	58,359	19,365	38,994	1,438	834	568	64	34	117	51	1,178	1,065	831	68	167	NA[b]
1982	73,657	7,375	61,864	20,247	41,617	1,409	853	573	66	37	123	54	1,061	1,095	853	71	171	NA[b]
1983	78,644	8,342	65,669	21,208	44,462	1,440	826	538	62	40	129	57	1,136	1,230	977	75	178	NA[b]
1984	87,276	9,320	72,906	23,226	49,680	1,390	869	557	67	47	138	60	1,299	1,492	1,218	86	188	NA[b]
1985	94,767	10,197	78,951	25,788	53,163	1,403	935	601	70	53	149	62	1,583	1,698	1,400	95	202	NA[b]
1986	94,051	10,268	78,013	26,699	51,314	1,421	1,004	637	79	61	163	63	1,865	1,480	1,163	105	212	NA[b]
1987	96,081	9,842	80,407	29,040	51,366	1,481	1,072	669	85	66	181	70	2,010	1,270	928	110	232	NA[b]
1988	98,270	10,295	81,707	27,547	54,160	1,642	1,249	802	93	74	200	79	2,046	843	473	116	254	488
1989	97,819	10,427	81,054	23,460	57,594	1,586	1,320	827	100	82	222	88	1,985	967	565	125	277	480
1990	100,512	10,359	83,700	20,254	63,446	1,536	1,451	931	104	88	236	93	1,853	1,088	661	133	294	523
1991[e]	97,814	9,019	82,496	17,731	64,765	1,421	1,560	1,025	106	88	245	96	1,579	1,191	742	140	309	547
1992	99,894	9,098	84,569	17,181	67,388	1,373	1,580	1,045	103	89	244	98	1,452	1,223	758	143	322	599
1993	97,203	8,840	82,596	15,673	66,923	1,013	1,614	1,064	106	93	248	102	1,339	1,242	767	144	332	560
1994	98,139	8,458	83,738	15,443	68,295	1,140	1,681	1,115	106	96	258	106	1,315	1,261	775	146	341	546
1995	105,466	8,868	90,496	16,570	73,926	1,124	1,697	1,117	109	99	266	106	1,529	1,194	701	154	338	558
1996 prelim.	109,326	8,450	94,944	16,018	78,925	1,099	1,686	1,094	111	103	271	107	1,495	1,183	677	163	343	469
1997 prelim.	113,651	7,688	100,178	15,505	84,673	1,071	1,732	1,128	113	106	276	109	1,457	1,126	604	171	351	400

FFRDCs = federally funded research and development centers; U&C = universities and colleges

NOTES: Data are based on annual reports by performers except for the nonprofit sector; R&D expenditures by nonprofit sector performers have been estimated since 1973 on the basis of a survey conducted in that year. The next updates of these data, covering the years 1953-98, along with technical notes explaining methodological issues of measurement, will be provided in National Science Foundation, Science Resources Studies Division (NSF/SRS), *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming). Data are preliminary for 1996 and 1997.

[a] Industry sources of industry R&D expenditures include all nonfederal sources of industry R&D expenditures.

[b] For 1953-63, development expenditures by industry FFRDCs were not separated out from total federal support to the industrial sector for development. Thus, the figure for federal support to industry for development includes support for development at industry FFRDCs for those years. The same is true for development by nonprofit FFRDCs in 1953-87, which is included in federal support for development at nonprofit institutions for those years.

[c] Includes R&D expenditures of FFRDCs administered by academic institutions. In 1994, 99 percent of total funds used were from federal sources.

[d] Expenditure levels for academic and Federal Government performers are also in reference to calendar years, which represents a change from previous reporting in *National Patterns of R&D Resources*. These levels are approximations based on fiscal year data. For 1977 and later years, the calendar year approximation is equal to 75 percent of the amount reported in the same fiscal year plus 25 percent of the amount reported in the subsequent fiscal year. For years prior to 1977, the respective percentages are 50 and 50, since earlier fiscal years began on July 1 instead of October 1.

[e] Due to revisions in survey methodology and sampling of industrial R&D, data for 1991 and subsequent years may not be comparable to data for previous years. See NSF/SRS, *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>; or NSF/SRS, *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming).

SOURCE: NSF/SRS, *National Patterns of R&D Resources* (Arlington, VA: biennial series).

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Appendix table 4-17.

U.S. development expenditures, by source of funds and performer: 1970-97

(Millions of current dollars)

Funding sector:	Total U.S.	Federal Government								Industry				U&Cs	Nonprofit			Nonfed. govt.[a]
Performing sector:	**Total U.S.**	**Total**	**Federal Govt.**	**Industry**	**Industry FFRDCs**	**U&Cs**	**U&C FFRDCs[b]**	**Non-profit**	**Nonprofit FFRDCs**	**Total**	**Industry[c]**	**U&Cs**	**Non-profit**	**U&Cs**	**Total**	**Non-profit**	**U&Cs**	**U&Cs[a]**
Calendar year[d]																		
1970	16,926	9,384	2,258	6,232	340	84	251	220	NA[e]	7,489	7,466	5	18	7	40	30	10	6
1971	17,395	9,557	2,473	6,167	391	76	257	194	NA[e]	7,781	7,757	5	19	8	42	33	9	7
1972	18,734	10,136	2,640	6,533	402	59	290	213	NA[e]	8,532	8,510	3	19	12	43	35	8	11
1973	20,193	10,310	2,658	6,621	399	70	295	268	NA[e]	9,798	9,773	5	20	19	50	38	12	17
1974	21,488	10,493	2,766	6,553	479	73	309	314	NA[e]	10,895	10,868	6	21	24	57	42	15	20
1975	22,691	10,977	2,890	6,783	535	80	359	330	NA[e]	11,599	11,569	8	22	27	67	51	16	21
1976	25,059	12,006	2,972	7,522	654	93	424	341	NA[e]	12,923	12,890	10	23	30	77	61	16	24
1977	27,655	13,133	3,188	8,275	675	133	503	359	NA[e]	14,369	14,328	14	27	37	90	73	17	26
1978	31,047	14,353	3,676	8,756	753	224	542	403	NA[e]	16,505	16,460	15	30	48	109	87	22	32
1979	35,460	16,053	3,944	9,888	810	325	603	483	NA[e]	19,195	19,145	15	35	53	126	99	27	34
1980	40,701	17,516	4,072	10,957	882	361	719	525	NA[e]	22,949	22,891	18	40	64	135	105	30	37
1981	46,060	19,973	4,530	12,791	950	375	778	549	NA[e]	25,824	25,756	23	45	77	144	110	34	42
1982	51,714	22,128	5,178	14,215	989	402	745	599	NA[e]	29,295	29,219	26	50	86	158	120	38	46
1983	57,560	24,622	6,106	15,522	1,054	393	832	715	NA[e]	32,626	32,542	29	55	95	172	130	42	46
1984	66,284	28,108	7,078	17,640	1,056	423	987	925	NA[e]	37,832	37,731	36	65	105	188	143	46	51
1985	74,444	32,187	8,011	20,258	1,102	472	1,244	1,100	NA[e]	41,878	41,762	41	75	117	208	159	49	55
1986	75,796	33,891	8,275	21,517	1,145	513	1,503	938	NA[e]	41,488	41,354	49	85	132	222	171	51	64
1987	79,809	36,524	8,176	24,122	1,230	556	1,669	771	NA[e]	42,813	42,667	55	91	150	251	193	58	71
1988	84,614	37,277	8,864	23,719	1,414	691	1,761	407	420	46,798	46,634	64	100	172	287	219	68	80
1989	87,767	35,289	9,355	21,049	1,423	742	1,781	507	430	51,862	51,676	74	112	199	327	248	79	90
1990	94,118	33,820	9,700	18,966	1,438	871	1,735	619	490	59,617	59,410	82	125	221	362	275	87	97
1991[f]	95,193	31,207	8,778	17,256	1,383	998	1,537	722	533	63,251	63,030	85	136	238	394	301	93	103
1992	99,894	31,506	9,098	17,181	1,373	1,045	1,452	758	599	67,620	67,388	89	143	244	420	322	98	103
1993	99,746	30,021	9,071	16,083	1,039	1,092	1,374	787	574	68,917	68,674	96	147	254	446	340	105	109
1994	103,005	30,219	8,877	16,209	1,196	1,171	1,380	814	574	71,934	71,681	101	153	271	469	357	111	111
1995	113,445	32,773	9,539	17,824	1,209	1,201	1,645	754	600	79,791	79,518	107	166	287	477	364	114	118
1996 prelim.	120,281	32,239	9,297	17,624	1,209	1,204	1,645	745	516	87,126	86,834	113	179	298	495	378	118	122
1997 prelim.	128,323	31,448	8,681	17,507	1,209	1,274	1,645	682	451	95,917	95,604	120	193	312	520	397	123	127

FFRDCs = federally funded research and development centers; U&C = universities and colleges

NOTES: Data are based on annual reports by performers except for the nonprofit sector; R&D expenditures by nonprofit sector performers have been estimated since 1973 on the basis of a survey conducted in that year. The next updates of these data, covering the years 1953-98, along with technical notes explaining methodological issues of measurement, will be provided in National Science Foundation, Science Resources Studies Division (NSF/SRS), *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming). Data are preliminary for 1996 and 1997.

[a] Because of limitations in the survey information, data on nonfederal government funding to other performers are not available, and are consequently included in other sectors' support for their own R&D performance. For example, nonfederal government support to nonprofits is included in nonprofits' support for their own R&D (data column 16).

[b] Includes R&D expenditures of FFRDCs administered by academic institutions. In 1994, 99 percent of total funds used were from federal sources.

[c] Industry sources of industry R&D expenditures include all nonfederal sources of industry R&D expenditures.

[d] Expenditure levels for academic and Federal Government performers are also in reference to calendar years, which represents a change from previous reporting in *National Patterns of R&D Resources*. These levels are approximations based on fiscal year data. For 1977 and later years, the calendar year approximation is equal to 75 percent of the amount reported in the same fiscal year plus 25 percent of the amount reported in the subsequent fiscal year. For years prior to 1977, the respective percentages are 50 and 50, since earlier fiscal years began on July 1 instead of October 1.

[e] For 1953-63, development expenditures by industry FFRDCs were not separated out from total federal support to the industrial sector for applied research. Thus, the figure for federal support to industry for applied research includes support for applied research at industry FFRDCs for those years. The same is true for applied research by nonprofit FFRDCs in 1953-87, which is included in federal support for applied research at nonprofit institutions for those years.

[f] Due to revisions in survey methodology and sampling of industrial R&D, data for 1991 and subsequent years may not be comparable to data for previous years. See NSF/SRS, *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>; or NSF/SRS, *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming).

SOURCE: NSF/SRS, *National Patterns of R&D Resources* (Arlington, VA: biennial series).

See figure 4-8.

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Appendix table 4-18.

U.S. development expenditures, by source of funds and performer: 1970-97

(Millions of constant 1992 dollars)

Funding sector:	Total U.S.	Federal Government								Industry				U&Cs	Nonprofit			Nonfed. govt.[a]
Performing sector:	Total U.S.	Total	Federal Govt.	Industry	Industry FFRDCs	U&Cs	U&C FFRDCs[b]	Non-profit	Nonprofit FFRDCs	Total	Industry[c]	U&Cs	Non-profit	U&Cs	Total	Non-profit	U&Cs	U&Cs[a]
Calendar year[d]																		
1970	55,383	30,704	7,387	20,391	1,112	274	820	720	NA[e]	24,504	24,429	16	59	23	131	98	33	21
1971	54,118	29,733	7,692	19,186	1,216	236	798	604	NA[e]	24,206	24,133	14	59	25	131	103	29	23
1972	55,906	30,248	7,877	19,496	1,200	175	864	636	NA[e]	25,463	25,396	10	57	35	128	104	24	32
1973	57,080	29,144	7,512	18,716	1,128	199	833	756	NA[e]	27,695	27,626	13	57	52	141	107	33	47
1974	55,773	27,235	7,178	17,009	1,243	189	802	814	NA[e]	28,280	28,209	16	55	61	147	109	38	51
1975	53,820	26,036	6,854	16,089	1,269	190	851	783	NA[e]	27,511	27,441	18	52	64	159	121	38	51
1976	56,166	26,908	6,661	16,859	1,466	209	949	764	NA[e]	28,965	28,890	23	52	67	173	137	36	53
1977	58,268	27,670	6,717	17,435	1,422	279	1,060	756	NA[e]	30,275	30,188	30	57	78	190	154	36	55
1978	60,968	28,186	7,219	17,195	1,479	440	1,064	790	NA[e]	32,411	32,323	29	59	94	215	171	44	62
1979	64,165	29,047	7,136	17,892	1,466	588	1,092	873	NA[e]	34,733	34,643	27	63	97	228	179	48	61
1980	67,408	29,009	6,745	18,147	1,461	597	1,190	869	NA[e]	38,008	37,912	30	66	106	224	174	50	61
1981	69,734	30,239	6,859	19,365	1,438	568	1,178	831	NA[e]	39,097	38,994	34	68	117	217	167	51	64
1982	73,657	31,517	7,375	20,247	1,409	573	1,061	853	NA[e]	41,726	41,617	37	71	123	225	171	54	66
1983	78,644	33,641	8,342	21,208	1,440	538	1,136	977	NA[e]	44,577	44,462	40	75	129	235	178	57	62
1984	87,276	37,010	9,320	23,226	1,390	557	1,299	1,218	NA[e]	49,813	49,680	47	86	138	248	188	60	67
1985	94,767	40,973	10,197	25,788	1,403	601	1,583	1,400	NA[e]	53,311	53,163	53	95	149	264	202	62	70
1986	94,051	42,054	10,268	26,699	1,421	637	1,865	1,163	NA[e]	51,480	51,314	61	105	163	275	212	63	79
1987	96,081	43,971	9,842	29,040	1,481	669	2,010	928	NA[e]	51,542	51,366	66	110	181	302	232	70	85
1988	98,270	43,293	10,295	27,547	1,642	802	2,046	473	488	54,351	54,160	74	116	200	333	254	79	93
1989	97,819	39,330	10,427	23,460	1,586	827	1,985	565	480	57,802	57,594	82	125	222	365	277	88	100
1990	100,512	36,117	10,359	20,254	1,536	931	1,853	661	523	63,667	63,446	88	133	236	387	294	93	104
1991[f]	97,814	32,066	9,019	17,731	1,421	1,025	1,579	742	547	64,993	64,765	88	140	245	404	309	96	106
1992	99,894	31,506	9,098	17,181	1,373	1,045	1,452	758	599	67,620	67,388	89	143	244	420	322	98	103
1993	97,203	29,255	8,840	15,673	1,013	1,064	1,339	767	560	67,160	66,923	93	144	248	434	332	102	106
1994	98,139	28,792	8,458	15,443	1,140	1,115	1,315	775	546	68,536	68,295	96	146	258	446	341	106	106
1995	105,466	30,468	8,868	16,570	1,124	1,117	1,529	701	558	74,179	73,926	99	154	266	444	338	106	109
1996 prelim.	109,326	29,303	8,450	16,018	1,099	1,094	1,495	677	469	79,191	78,925	103	163	271	450	343	107	111
1997 prelim.	113,651	27,852	7,688	15,505	1,071	1,128	1,457	604	400	84,950	84,673	106	171	276	460	351	109	113

FFRDCs = federally funded research and development centers; U&C = universities and colleges

NOTES: Data are based on annual reports by performers except for the nonprofit sector; R&D expenditures by nonprofit sector performers have been estimated since 1973 on the basis of a survey conducted in that year. The next updates of these data, covering the years 1953-98, along with technical notes explaining methodological issues of measurement, will be provided in National Science Foundation, Science Resources Studies Division (NSF/SRS), *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming). Data are preliminary for 1996 and 1997.

[a] Because of limitations in the survey information, data on nonfederal government funding to other performers are not available, and are consequently included in other sectors' support for their own R&D performance. For example, nonfederal government support to nonprofits is included in nonprofits' support for their own R&D (data column 16).

[b] Includes R&D expenditures of FFRDCs administered by academic institutions. In 1994, 99 percent of total funds used were from federal sources.

[c] Industry sources of industry R&D expenditures include all nonfederal sources of industry R&D expenditures.

[d] Expenditure levels for academic and Federal Government performers are also in reference to calendar years, which represents a change from previous reporting in *National Patterns of R&D Resources*. These levels are approximations based on fiscal year data. For 1977 and later years, the calendar year approximation is equal to 75 percent of the amount reported in the same fiscal year plus 25 percent of the amount reported in the subsequent fiscal year. For years prior to 1977, the respective percentages are 50 and 50, since earlier fiscal years began on July 1 instead of October 1.

[e] For 1953-63, development expenditures by industry FFRDCs were not separated out from total federal support to the industrial sector for applied research. Thus, the figure for federal support to industry for applied research includes support for applied research at industry FFRDCs for those years. The same is true for applied research by nonprofit FFRDCs in 1953-87, which is included in federal support for applied research at nonprofit institutions for those years.

[f] Due to revisions in survey methodology and sampling of industrial R&D, data for 1991 and subsequent years may not be comparable to data for previous years. See NSF/SRS, *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>; or NSF/SRS, *National Patterns of R&D Resources: 1998* (Arlington, VA: forthcoming).

SOURCE: NSF/SRS, *National Patterns of R&D Resources* (Arlington, VA: biennial series).

See figure 4-7.

Appendix table 4-19.
Manufacturing and nonmanufacturing R&D expenditures: 1970-95

	All industries			All manufacturing industries			All nonmanufacturing industries		
	Total	Company	Federal	Total	Company	Federal	Total	Company	Federal
				Millions of current dollars					
1970	18,067	10,288	7,779	17,362	10,063	7,299	705	225	480
1971	18,320	10,654	7,666	17,616	10,402	7,214	704	252	452
1972	19,552	11,535	8,017	18,845	11,258	7,587	707	277	430
1973	21,249	13,104	8,145	20,534	12,805	7,729	715	299	416
1974	22,887	14,667	8,220	22,119	14,362	7,757	768	305	463
1975	24,187	15,582	8,605	23,452	15,157	8,295	735	425	310
1976	26,997	17,436	9,561	26,152	16,965	9,187	845	471	374
1977	29,825	19,340	10,485	28,867	18,799	10,068	958	541	417
1978	33,304	22,115	11,189	32,075	21,413	10,662	1,229	702	527
1979	38,226	25,708	12,518	36,686	24,849	11,837	1,540	859	681
1980	44,505	30,476	14,029	42,690	29,439	13,251	1,815	1,037	778
1981	51,810	35,428	16,382	49,904	34,380	15,524	1,906	1,048	858
1982	58,650	40,105	18,545	56,178	38,633	17,545	2,472	1,472	1,000
1983	65,268	44,588	20,680	61,931	42,504	19,427	3,337	2,084	1,253
1984	74,800	51,404	23,396	69,895	48,152	21,743	4,905	3,252	1,653
1985	84,239	57,403	27,196	77,525	52,642	24,883	6,714	4,401	2,313
1986	87,823	59,932	27,891	80,377	55,192	25,185	7,446	4,740	2,706
1987	92,155	61,403	30,752	84,311	56,259	28,052	7,844	5,144	2,700
1988	97,015	66,672	30,343	86,503	59,415	27,088	10,513	7,257	3,256
1989	102,055	73,501	28,554	88,024	63,199	24,826	14,031	10,302	3,729
1990	109,727	81,602	28,125	88,934	65,251	23,683	20,793	16,351	4,442
1991	116,952	90,580	26,372	88,506	67,639	20,867	28,446	22,941	5,505
1992	119,110	94,388	24,722	90,177	71,025	19,152	28,933	23,363	5,570
1993	117,400	94,591	22,809	86,569	69,901	16,669	30,831	24,690	6,140
1994	119,595	97,131	22,463	90,749	73,375	17,373	28,846	23,756	5,090
1995	132,103	108,652	23,451	100,067	81,236	18,831	32,036	27,415	4,620
				Millions of constant 1992 dollars[a]					
1970	59,116	33,663	25,453	56,809	32,927	23,883	2,307	736	1,571
1971	56,995	33,146	23,850	54,805	32,362	22,443	2,190	784	1,406
1972	58,349	34,424	23,925	56,239	33,597	22,642	2,110	827	1,283
1973	60,066	37,042	23,024	58,045	36,197	21,848	2,021	845	1,176
1974	59,405	38,069	21,336	57,412	37,278	20,134	1,993	792	1,202
1975	57,370	36,959	20,410	55,626	35,951	19,675	1,743	1,008	735
1976	60,508	39,079	21,429	58,614	38,024	20,591	1,894	1,056	838
1977	62,840	40,748	22,091	60,821	39,609	21,213	2,018	1,140	879
1978	65,401	43,428	21,972	62,987	42,050	20,937	2,413	1,379	1,035
1979	69,170	46,519	22,651	66,383	44,964	21,419	2,787	1,554	1,232
1980	73,708	50,474	23,235	70,702	48,756	21,946	3,006	1,717	1,289
1981	78,439	53,637	24,802	75,554	52,051	23,503	2,886	1,587	1,299
1982	83,536	57,122	26,414	80,015	55,026	24,990	3,521	2,097	1,424
1983	89,175	60,920	28,255	84,616	58,073	26,543	4,559	2,847	1,712
1984	98,488	67,683	30,805	92,030	63,401	28,629	6,458	4,282	2,176
1985	107,236	73,074	34,620	98,689	67,013	31,676	8,547	5,602	2,944
1986	108,975	74,367	34,609	99,736	68,485	31,251	9,239	5,882	3,358
1987	110,945	73,923	37,022	101,501	67,730	33,772	9,443	6,193	3,251
1988	112,672	77,432	35,240	100,463	69,004	31,460	12,210	8,428	3,781
1989	113,743	81,919	31,824	98,105	70,437	27,669	15,638	11,482	4,156
1990	117,181	87,145	30,036	94,975	69,684	25,292	22,205	17,462	4,744
1991	120,171	93,073	27,098	90,942	69,501	21,441	29,229	23,573	5,657
1992	119,110	94,388	24,722	90,177	71,025	19,152	28,933	23,363	5,570
1993	114,407	92,180	22,228	84,362	68,119	16,244	30,045	24,061	5,983
1994	113,946	92,543	21,402	86,462	69,909	16,552	27,483	22,634	4,850
1995	122,812	101,011	21,802	93,029	75,523	17,507	29,783	25,487	4,295

NOTES: As a result of a new sample design, statistics for 1988-91 have been revised. These statistics now better reflect R&D performance among firms in nonmanufacturing industries and small firms in all industries.

[a] See appendix table 4-1 for GDP implicit price deflators used to convert current dollars to constant 1992 dollars.

SOURCE: National Science Foundation, Science Resources Studies Division, *Research and Development in Industry: 1995* (Arlington, VA: 1998, forthcoming).

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Appendix table 4-20.

Total expenditures for industrial R&D (financed by company, federal, and other funds), by industry and size of company: 1985-95

(Millions of current dollars)

Industry and size of company	SIC code	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Total		84,239	87,823	92,155	97,015	102,055	109,727	116,952	119,110	117,400	119,595	132,103
Manufacturing		77,525	80,377	84,311	86,503	88,024	88,934	88,506	90,177	86,569	90,749	100,067
Food, kindred, and tobacco products	20,21	D	D	1,206	D	D	D	1,277	1,386	1,345	1,476	1,566
Textiles and apparel	22,23	D	D	D	D	D	D	D	D	D	D	D
Lumber, wood products, and furniture	24,25	147	144	137	D	192	216	D	D	D	D	D
Paper and allied products	26	D	D	D	D	879	1,059	D	D	D	D	D
Chemicals and allied products	28	8,540	8,843	9,635	11,067	12,069	13,291	14,648	15,381	D	D	17,547
Industrial chemicals	281-82,286	3,498	3,552	3,716	4,172	4,451	5,010	5,390	5,165	D	D	D
Drugs and medicines	283	D	3,658	D	4,906	D	D	D	7,944	9,146	9,633	10,215
Other chemicals	284-85,287-89	D	1,633	D	1,989	D	D	D	2,272	D	D	D
Petroleum refining and extraction	13,29	D	D	1,897	1,997	2,180	2,306	2,498	2,277	2,152	1,950	1,760
Rubber products	30	D	D	D	D	D	D	D	D	D	D	D
Stone, clay, and glass products	32	D	950	995	D	D	D	D	D	538	591	448
Primary metals	33	D	D	730	637	686	739	714	522	669	690	593
Ferrous metals and products	331-32,3398-99	D	D	D	253	D	D	D	D	289	D	D
Nonferrous metals and products	333-36	416	458	D	384	D	D	D	D	380	D	D
Fabricated metal products	34	829	895	783	881	904	939	974	1,017	1,158	1,111	1,023
Machinery	35	12,216	D	D	D	D	14,446	14,775	14,938	8,381	8,110	D
Office, computing, and accounting machines	357	D	D	D	D	D	D	D	D	4,950	4,106	D
Other machinery, except electrical	351-56,358-59	D	2,396	2,428	2,682	2,729	D	D	D	3,431	4,004	5,041
Electrical equipment	36	14,432	14,980	15,848	14,128	13,318	13,400	13,415	13,360	13,349	15,338	18,751
Radio and TV receiving equipment	365	D	133	139	149	96	114	D	D	D	D	D
Communication equipment	366	9,397	9,669	10,184	8,427	7,071	5,928	4,787	D	D	D	D
Electronic components	367	3,385	D	4,286	4,133	4,025	3,914	D	3,567	5,311	6,032	D
Other electrical equipment	361-64,369	D	D	1,239	1,419	2,126	3,444	D	D	D	D	D
Transportation equipment	37	D	31,275	34,246	34,775	33,859	31,361	27,428	27,494	27,258	28,087	32,441
Motor vehicles and motor vehicles equipment	371	6,984	D	D	D	D	D	D	D	11,718	D	D
Other transportation equipment	373-75,379	D	D	D	D	D	D	D	D	483	D	D
Aircraft and missiles	372,376	22,231	21,050	24,458	24,168	22,331	20,635	16,629	17,158	15,056	14,260	16,951
Professional and scientific instruments	38	5,013	5,103	5,222	5,530	5,992	7,055	8,705	9,542	10,119	11,441	11,976
Scientific and mechanical measuring instruments	381-82	D	D	D	1,959	2,366	3,346	D	5,156	5,681	6,952	7,146
Optical, surgical, photographic, and other instruments	384-87	D	D	D	3,571	3,626	3,709	D	4,386	4,438	4,489	4,831
Other manufacturing industries	27,31,39	D	382	D	D	D	D	D	D	D	D	D
Nonmanufacturing		6,714	7,446	7,844	10,513	14,031	20,793	28,446	28,933	30,831	28,846	32,036

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Appendix table 4-20.

Total expenditures for industrial R&D (financed by company, federal, and other funds), by industry and size of company: 1985-95

(Millions of current dollars)

Industry and size of company	SIC code	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Size												
Fewer than 500 employees		5,866	7,071	7,163	S	7,809	S	13,172	13,557	14,620	13,966	16,662
500 to 999		1,648	1,902	1,725	1,669	1,825	2,154	8,000	7,958	3,230	3,608	4,693
1,000 to 4,999		6,240	7,472	7,262	7,622	7,881	8,411	10,453	11,886	13,334	14,617	16,960
5,000 to 9,999		4,022	4,251	4,501	5,245	5,756	6,746	8,049	8,258	9,135	8,912	9,532
10,000 to 24,999		11,109	10,493	12,043	11,506	10,450	12,486	15,770	15,744	15,421	15,972	17,071
25,000 or more		55,354	56,991	59,461	63,694	68,335	71,030	61,508	61,707	61,659	62,519	67,185

D = data have been withheld to avoid disclosing operations of individual companies; S = imputation of more than 50 percent (for years prior to 1993, data have been withheld); SIC = Standard Industrial Classification

NOTES: As a result of a new sample design, statistics for 1988-91 have been revised since originally published. These statistics now better reflect R&D performance among firms in the nonmanufacturing industries and small firms in all industries. As a result of the new sample design, data for 1991 and later years are not directly comparable with data for 1990 and earlier years.

SOURCE: National Science Foundation, Science Resources Studies Division, *Research and Development in Industry: 1995* (Arlington, VA: 1998, forthcoming).

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Appendix table 4-21.

Company and other (except federal) funds for industrial R&D performance, by industry and size of company: 1985-95

(Millions of current dollars)

Industry and size of company	SIC code	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Total		57,043	59,932	61,403	66,672	73,501	81,602	90,580	94,388	94,591	97,131	108,652
Manufacturing		52,642	55,192	56,259	59,415	63,199	65,251	67,639	71,025	69,901	73,375	81,236
Food, kindred, and tobacco products	20,21	1,136	1,280	1,204	1,173	1,244	1,248	1,277	1,386	1,345	1,476	1,566
Textiles and apparel	22,23	218	246	243	215	S	260	236	261	286	316	381
Lumber, wood products, and furniture	24,25	147	144	137	165	192	216	200	234	196	201	229
Paper and allied products	26	576	538	604	752	879	1,059	1,174	1,182	1,191	1,263	1,404
Chemicals and allied products	28	8,310	8,664	9,445	10,828	11,943	13,168	14,439	15,091	16,658	16,559	17,337
Industrial chemicals	281-82,286	3,281	3,374	3,531	3,939	4,340	4,902	5,225	4,911	5,165	4,780	5,139
Drugs and medicines	283	3,481	3,657	4,095	4,900	5,512	5,917	6,947	7,934	9,132	9,625	10,202
Other chemicals	284-85,287-89	1,548	1,633	1,819	1,989	2,091	2,349	2,267	2,246	2,361	2,154	1,996
Petroleum refining and extraction	13,29	2,194	1,971	1,883	1,975	2,162	2,289	2,487	2,268	2,138	1,939	1,754
Rubber products	30	659	655	596	718	867	1,056	D	1,256	1,059	1,432	1,210
Stone, clay, and glass products	32	825	941	985	697	615	538	455	479	529	553	441
Primary metals	33	730	786	711	620	666	717	706	514	646	672	580
Ferrous metals and products	331-32,3398-99	323	336	249	252	244	231	225	221	272	241	217
Nonferrous metals and products	333-36	407	450	462	368	422	486	481	293	374	431	363
Fabricated metal products	34	780	800	633	718	726	736	748	723	936	868	937
Machinery	35	10,721	10,701	10,577	11,929	13,342	13,575	13,720	13,903	8,295	8,011	9,676
Office, computing, and accounting machines	357	8,418	8,380	8,193	9,347	10,725	10,988	10,419	10,614	4,917	4,078	4,699
Other machinery, except electrical	351-56,358-59	2,303	2,321	2,384	2,582	2,618	2,587	3,301	3,289	3,378	3,933	4,976
Electrical equipment	36	9,271	9,767	10,449	9,975	9,575	9,267	8,865	9,516	11,682	13,537	17,060
Radio and TV receiving equipment	365	350	133	139	149	96	114	D	93	87	64	114
Communication equipment	366	5,174	5,117	5,455	4,798	4,159	3,584	S	3,381	3,954	4,939	3,845
Electronic components	367	2,826	3,357	3,630	3,684	3,655	3,496	3,177	3,320	5,105	5,870	9,628
Other electrical equipment	361-64,369	921	1,160	1,225	1,345	1,664	2,073	D	2,722	2,537	2,664	3,473
Transportation equipment	37	12,092	13,567	13,462	13,910	14,596	14,264	14,858	16,292	16,640	17,695	19,311
Motor vehicles and motor vehicles equipment	371	6,164	7,171	7,167	7,783	8,756	8,594	9,063	9,132	10,659	11,950	13,590
Other transportation equipment	373-75,379	279	330	356	361	337	283	262	289	297	279	232
Aircraft and missiles	372,376	5,649	6,066	5,939	5,766	5,503	5,387	5,533	6,871	5,684	5,466	5,489
Professional and scientific instruments	38	4,622	4,752	4,950	5,339	5,729	6,318	6,840	7,321	7,542	8,058	8,516
Scientific and mechanical measuring instruments	381-82	1,596	1,521	1,598	1,863	2,205	2,696	3,017	3,013	3,196	3,687	3,787
Optical, surgical, photographic, and other instruments	384-87	3,026	3,231	3,352	3,476	3,524	3,621	3,823	4,308	4,346	4,371	4,729
Other manufacturing industries	27,31,39	361	380	380	401	438	541	D	599	758	796	835
Nonmanufacturing		4,401	4,740	5,144	7,257	10,302	16,351	22,941	23,363	24,690	23,756	27,415

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Appendix table 4-21.

Company and other (except federal) funds for industrial R&D performance, by industry and size of company: 1985-95
(Millions of current dollars)

Industry and size of company	SIC code	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Size												
Fewer than 500 employees		5,127	6,203	6,200	S	S	S	11,285	11,532	13,006	12,802	14,684
500 to 999		1,531	1,765	1,610	1,748	1,934	2,144	7,819	7,807	3,048	3,426	4,468
1,000 to 4,999		5,249	6,243	6,281	6,820	7,546	8,363	9,403	10,865	12,219	13,533	16,162
5,000 to 9,999		3,350	3,455	3,753	4,075	4,509	4,997	7,233	7,495	8,371	8,087	9,289
10,000 to 24,999		8,366	8,489	9,681	10,512	11,631	12,890	12,397	12,328	12,606	13,625	15,125
25,000 or more		33,420	33,777	33,878	36,785	40,703	45,106	42,443	44,361	45,340	45,658	48,924

D = data have been withheld to avoid disclosing operations of individual companies; S = imputation of more than 50 percent (for years prior to 1993, data have been withheld); SIC = Standard Industrial Classification

NOTES: Company funds include funds for industrial R&D work performed within company facilities from all sources except the Federal Government. The funds may be the companies' own or from outside organizations such as research institutions, universities and colleges, nonprofit organizations, other companies, and state governments. Company-financed R&D not performed within the company is excluded. As a result of a new sample design, statistics for 1988-91 have been revised since originally published. These statistics now better reflect R&D performance among firms in the nonmanufacturing industries and small firms in all industries. As a result of the new sample design, data for 1991 and later years are not directly comparable with data for 1990 and earlier years.

SOURCE: National Science Foundation, Science Resources Studies Division, *Research and Development in Industry: 1995* (Arlington, VA: 1998, forthcoming).

See text table 4-3.

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Appendix table 4-22.

Federal funds for industrial R&D performance, by industry and size of company: 1985-95

(Millions of current dollars)

Industry and size of company	SIC code	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	
Total		27,196	27,891	30,752	30,343	28,554	28,125	26,372	24,722	22,809	22,463	23,451	
Manufacturing		24,883	25,185	28,052	27,088	24,826	23,683	20,867	19,152	16,669	17,373	18,831	
Food, kindred, and tobacco products	20,21	D	D	2	D	D	D	0	0	0	0	0	
Textiles and apparel	22,23	D	D	D	D	D	D	S	D	D	D	D	
Lumber, wood products, and furniture	24,25	0	0	0	D	0	0	D	D	D	D	D	
Paper and allied products	26	D	D	D	D	0	0	D	D	D	D	D	
Chemicals and allied products	28	230	179	190	238	126	123	209	S	D	D	210	S
Industrial chemicals	281-82,286	217	178	185	232	111	109	165	S	D	D	D	
Drugs and medicines	283	D	1	D	6	D	D	D	S	15	8	14	
Other chemicals	284-85,287-89	D	0	D	0	D	D	D	S	D	D	D	
Petroleum refining and extraction	13,29	D	D	14	22	S	S	11	9	14	10	6	
Rubber products	30	D	D	D	D	D	D	D	D	D	D	D	
Stone, clay, and glass products	32	D	9	10	D	D	D	D	D	9	38	6	
Primary metals	33	D	D	19	17	22	D	8	S	23	17	13	
Ferrous metals and products	331-32,3398-99	D	D	D	1	D	D	1	D	17	D	D	
Nonferrous metals and products	333-36	9	8	D	16	D	D	7	D	6	D	D	
Fabricated metal products	34	49	95	150	163	178	203	226	294	222	243	86	
Machinery	35	1,495	D	D	D	D	871	1,055	1,035	86	99	D	
Office, computing, and accounting machines	357	D	D	D	D	D	D	D	D	33	28	D	
Other machinery, except electrical	351-56,358-59	D	75	44	101	112	D	D	D	53	71	64	
Electrical equipment	36	5,161	5,213	5,399	4,153	3,743	4,133	4,550	3,844	1,667	1,801	1,690	
Radio and TV receiving equipment	365	D	0	0	0	0	0	0	D	D	D	D	
Communication equipment	366	4,223	4,552	4,729	3,630	2,911	2,344	D	D	D	D	D	
Electronic components	367	559	D	656	449	369	418	D	247	206	162	D	
Other electrical equipment	361-64,369	D	D	14	74	463	1,371	D	D	D	D	D	
Transportation equipment	36	D	17,708	20,784	20,865	19,262	17,097	12,570	11,202	10,617	10,392	13,130	
Motor vehicles and motor vehicles equipment	371	820	D	D	D	D	D	D	D	D	D	D	
Other transportation equipment	373-75,379	D	D	D	D	D	D	D	D	D	D	D	
Aircraft and missiles	372-376	16,582	14,984	18,519	18,402	16,828	15,248	11,096	S	9,372	8,794	11,462	
Professional and scientific instruments	38	391	351	272	191	263	737	1,865	2,221	2,577	3,384	3,460	S
Scientific and mechanical measuring instruments	381-82	D	D	D	S	S	S	D	2,143	2,484	3,266	3,358	S
Optical, surgical, photographic, and other instruments	384-87	D	D	D	95	101	87	D	78	92	118	102	
Other manufacturing industries	27,31,39	D	2	D	D	D	D	D	61	D	D	D	
Nonmanufacturing industries		2,313	2,706	2,700	3,256	3,729	4,442	5,505	5,570	6,140	5,090	4,620	

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Appendix table 4-22.

Federal funds for industrial R&D performance, by industry and size of company: 1985-95

(Millions of current dollars)

Industry and size of company	SIC Code	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Size												
Fewer than 500 employees		739	868	963	816	901	895	1,887	2,025	1,614	1,164	1,978
500 to 999		117	137	115	131	117	S	181	151	182	182	225
1,000 to 4,999		991	1,229	981	1,093	958	881	1,050	S	1,115	1,083	798
5,000 to 9,999		672	796	748	864	740	257	816	763	764	825	243
10,000 to 24,999		2,743	2,004	2,362	1,705	1,129	1,526	3,373	3,416	2,816	2,348	1,946 S
25,000 or more		21,934	23,213	25,583	25,734	24,709	24,436	19,065	17,346	16,319	16,862	18,261

D = data have been withheld to avoid disclosing operations of individual companies; S = imputation of more than 50 percent (for years prior to 1993, data have been withheld);
SIC = Standard Industrial Classification

NOTE: As a result of a new sample design, statistics for 1988-91 have been revised since originally published. These statistics now better reflect R&D performance among firms in the nonmanufacturing industries and small firms in all industries.

SOURCE: National Science Foundation, Science Resources Studies Division, *Research and Development in Industry: 1995* (Arlington, VA: 1998, forthcoming).

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Appendix table 4-23.

The 100 leading industrial R&D companies, ranked by size of R&D expenditures in 1996

1996 rank	1986 rank	Company	R&D expenditures (millions)	R&D/net sales (%)
1	1	General Motors	8,900.0	5.6
2	3	Ford Motor	6,821.0	4.6
3	2	IBM	3,934.0	5.2
4	9	Hewlett-Packard	2,718.0	7.1
5	20	Motorola	2,394.0	8.6
6	4	Lucent Technologies[a]	2,056.0	13.0
7	66	TRW[a]	1,981.0	20.1
8	18	Johnson & Johnson	1,905.0	8.8
9	46	Intel	1,808.0	8.7
10	31	Pfizer	1,684.0	14.9
11	12	Chrysler	1,600.0	2.7
12	22	Merck	1,487.3	7.5
13	–	Microsoft	1,432.0	16.5
14	47	American Home Products	1,429.1	10.1
15	5	General Electric	1,421.0	1.8
16	35/63	Bristol Myers Squibb	1,276.0	8.5
17	33	Pharmacia & Upjohn	1,266.0	17.4
18	23	Procter & Gamble	1,221.0	3.5
19	38	Abbott Laboratories	1,204.8	10.9
20	11	Boeing	1,200.0	5.3
21	26	Lilly	1,189.5	16.2
22	26	Texas Instruments	1,181.0	11.9
23	8	United Technologies	1,122.0	4.8
24	10	Digital Equipment	1,062.3	7.3
25	13	Xerox	1,044.0	6.0
26	6	Dupont	1,032.0	2.7
27	7	Eastman Kodak	1,028.0	6.4
28	16	3M	947.0	6.7
29	–	Rhone-Poulenc	882.1	16.3
30	21/51	Lockheed Martin	784.0	2.9
31	15	Dow Chemical	761.0	3.8
32	17	Monsanto	728.0	7.9
33	53	Schering-Plough	722.8	12.8
34	28	Rockwell International	691.0	6.7
35	–	Sun Microsystems, Inc.	657.1	9.3
36	4	AT&T[a]	640.0	1.2
37	75	Apple Computer	604.0	6.1
38	58	Warner-Lambert	554.8	7.7
39	54	ITT Industries	535.2	6.1
40	–	Amgen	528.3	23.6
41	14	Exxon	520.0	0.4
42	–	Seagate Technology	519.1	6.0
43	78	Philip Morris	515.0	0.9
44	–	Applied Materials	481.4	11.6
45	32	NCR	444.0	6.4
46	–	Genentech	434.1	51.3
47	61	Caterpillar	410.0	2.5
48	–	Compaq Computer	407.0	2.2
49	60	Advanced Micro Devices	400.7	20.5
50	–	Cisco Systems	399.3	9.7
51	67	Emerson Electric	398.7	3.6
52	37	Goodyear Tire & Rubber	374.5	2.9
53	–	Chiron	371.1	30.7
54	49	Deere	370.3	3.3

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Appendix table 4-23.

The 100 leading industrial R&D companies, ranked by size of R&D expenditures in 1996

1996 rank	1986 rank	Company	R&D expenditure (millions)	R&D/net sales (%)
55	19	McDonnell Douglas	355.0	2.6
56	–	Silicon Graphics	353.5	12.1
57	42	Honeywell	353.3	4.8
58	99	Tandem Computers	345.4	18.2
59	24	AlliedSignal	345.0	2.5
60	25	Unisys	342.9	5.4
61	56	Baxter International	340.0	6.3
62	41	Raytheon	323.3	2.6
63	62	AMP	315.1	5.8
64	–	Novell	275.6	20.0
65	45	Mobil	275.0	0.4
66	73	Eaton	267.0	3.8
67	29	Northrop Grumman	255.0	3.2
68	–	Bay Networks	253.2	12.3
69	–	Automatic Data Processing	249.6	7.0
70	55	PPG Industries	239.1	3.3
71	–	Cummins Engine	235.0	4.5
72	–	Boston Scientific	212.3	14.5
73	–	Genzyme	211.5	40.8
74	–	DSC Communications	210.1	15.2
75	82	Ingersoll-Rand	209.3	3.1
76	–	General Instrument	209.3	7.8
77	83	Kimberly-Clark	207.9	1.6
78	–	Gillette	204.0	2.1
79	–	LSI Logic	200.5	16.2
80	–	Whirlpool	197.0	2.3
81	–	Case	193.0	3.6
82	–	Micron Technology	191.9	5.3
83	86	Corning	191.3	5.2
84	–	RJR Nabisco	191.0	1.1
85	69	FMC	189.4	3.8
86	74	Rohm & Haas	187.0	4.7
87	84	Textron	185.0	2.0
88	–	Eastman Chemical	184.0	3.8
89	48	Chevron	182.0	0.5
90	–	Tellabs	181.9	20.9
91	–	Analog Devices	177.8	14.9
92	–	Storage Technology	176.4	8.7
93	–	Lam Research	173.0	13.6
94	44	Shell Oil	173.0	0.6
95	–	Sybase	172.0	17.0
96	52	Amoco	171.0	0.5
97	72	Alcoa	165.5	1.3
98	–	Johnson Controls	165.0	1.6
99	–	Dana	164.0	2.1
100	64	NYNEX	163.1	1.2

– = company unranked in 1986; X/X = 1986 ranking of each company before merger

[a] Lucent Technologies was split off from ATT in 1996. TRW restated its R&D expenses reported to the Securities and Exchange Commission in 1996 to include *all* "sponsor-supported" R&D, which means that federal R&D funds are now included in the company's total.

SOURCE: Technical Insights, *Inside R&D*, weekly newsletter (Englewood, NJ: John Wiley & Sons, Inc.).

Appendix table 4-24.

Concentration of total, federal, company, and other R&D funds and net sales of R&D-performing companies, by size of R&D program: 1985-95

Companies ranked by size of R&D program	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Percent of total (company, federal, and other) R&D funds											
First 4 (1-4)	18	19	19	18	19	18	16	15	17	15	16
Next 4 (5-8)	12	11	12	12	13	13	8	8	7	8	8
Next 12 (9-20)	17	14	16	17	16	15	12	13	13	14	13
Next 20 (21-40)	13	13	12	12	12	12	11	11	12	13	12
Next 60 (41-100)	16	15	14	15	15	16	15	15	16	15	14
Next 100 (101-200)	9	10	8	8	8	9	12	12	8	9	8
Next 200 (201-400)	5	8	6	7	6	7	6	6	7	7	7
Percent of federal R&D funds											
First 4 (1-4)	29	30	31	31	36	38	14	11	23	26	35
Next 4 (5-8)	15	16	18	18	15	16	21	18	17	19	19
Next 12 (9-20)	27	28	27	27	30	26	21	27	32	32	27
Next 20 (21-40)	16	15	15	15	11	12	15	13	16	13	8
Next 60 (41-100)	7	7	7	6	6	6	13	11	5	7	5
Next 100 (101-200)	2	2	1	3	1	1	3	4	5	2	3
Next 200 (201-400)	0	1	0	0	0	0	2	2	2	1	3
Percent of company and other (except federal) R&D funds											
First 4 (1-4)	23	20	20	21	22	21	17	17	17	16	16
Next 4 (5-8)	7	7	7	7	7	7	7	8	7	7	7
Next 12 (9-20)	12	12	12	12	13	12	10	12	12	12	11
Next 20 (21-40)	12	10	11	12	12	13	10	11	11	11	11
Next 60 (41-100)	18	16	16	16	16	17	16	17	14	14	14
Next 100 (101-200)	10	10	10	10	10	10	15	14	9	9	9
Next 200 (201-400)	7	8	8	8	8	8	7	7	8	8	8
Percent of net sales ranked by size of total R&D funds											
First 4 (1-4)	8	8	7	7	6	8	7	8	8	8	8
Next 4 (5-8)	4	5	5	5	5	4	3	3	3	2	2
Next 12 (9-20)	5	5	5	5	5	5	4	4	4	5	6
Next 20 (21-40)	8	7	7	6	5	5	4	4	4	5	4
Next 60 (41-100)	12	10	11	11	12	12	12	12	11	10	9
Next 100 (101-200)	13	10	8	9	8	9	9	9	8	8	8
Next 200 (201-400)	15	9	12	10	11	12	11	11	10	10	10

NOTES: Companies were ranked individually for each year; therefore, particular companies comprising the size groups may have changed from year to year. As a result of a new sample design, statistics for 1988-91 have been revised since originally published. These statistics now better reflect R&D performance among firms in the nonmanufacturing industries and small firms in all industries. See the technical notes for more information.

SOURCE: National Science Foundation, Science Resources Studies Division, *Research and Development in Industry: 1995* (Arlington, VA: 1998, forthcoming).

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Appendix table 4-25.

Company and other (except federal) R&D funds as a percentage of net sales for industrial R&D performance, by industry and size of company: 1985-95

(Percentages)

Industry and size of company	SIC code	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Total		NA	NA	NA	NA	NA	NA	NA	NA	NA	2.7	2.8
Manufacturing		3.0	3.2	3.1	3.1	3.1	3.1	3.2	3.3	3.1	2.9	2.9
Food, kindred, and tobacco products	20,21	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Textiles and apparel	22,23	0.5	0.5	0.4	0.4	0.5	0.6	0.6	0.6	0.6	0.6	0.9
Lumber, wood products, and furniture	24,25	0.8	0.6	0.6	0.6	0.6	0.6	0.9	0.9	0.7	0.6	0.7
Paper and allied products	26	0.8	0.7	0.6	0.8	0.8	1.0	1.1	1.0	1.1	1.0	1.0
Chemicals and allied products	28	4.9	5.1	5.2	5.2	5.4	5.3	5.3	5.4	6.0	5.1	4.7
Industrial chemicals	281-82,286	4.2	4.4	4.4	4.2	4.1	4.4	4.4	4.4	4.4	3.3	3.9
Drugs and medicines	283	8.0	8.4	8.7	8.8	8.9	8.8	8.9	9.6	12.5	10.2	10.4
Other chemicals	284-85,287-89	3.1	3.3	3.3	3.4	3.9	3.4	3.0	2.7	2.7	2.5	1.4
Petroleum refining and extraction	13,29	0.9	1.1	1.0	1.0	0.9	0.9	1.0	0.9	0.9	0.8	0.7
Rubber products	30	1.8	1.7	1.6	1.7	1.9	2.1	2.3	2.3	2.1	2.3	1.6
Stone, clay, and glass products	32	2.3	2.4	2.5	2.0	1.8	1.7	1.6	1.6	1.5	1.5	1.5
Primary metals	33	0.9	1.0	0.9	0.7	0.7	0.8	0.8	0.6	0.7	0.6	0.5
Ferrous metals and products	331-32,3398-99	0.5	0.7	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.3	0.3
Nonferrous metals and products	333-36	1.4	1.5	1.3	1.0	1.0	1.2	1.2	0.7	1.2	0.9	0.7
Fabricated metal products	34	1.4	1.4	1.2	1.1	1.2	1.1	1.2	1.1	1.1	1.0	1.1
Machinery	35	6.7	7.3	7.1	6.8	7.3	7.2	7.5	7.3	4.5	3.8	3.6
Office, computing, and accounting machines	357	12.4	12.4	12.3	11.2	13.1	14.4	14.9	13.7	9.8	7.9	8.1
Other machinery, except electrical	351-56,358-59	2.6	2.9	3.0	2.8	2.6	2.3	2.9	2.9	2.5	2.5	2.4
Electrical equipment	36	4.8	5.1	5.4	5.3	5.2	4.5	4.3	4.0	5.4	5.2	5.4
Radio and TV receiving equipment	365	4.3	3.6	3.2	2.4	1.8	1.6	1.0	0.6	4.0	1.0	1.6
Communication equipment	366	5.4	5.2	5.5	6.1	6.8	6.1	S	7.0	10.1	10.3	8.0
Electronic components	367	8.2	9.2	8.5	8.0	7.7	7.4	7.2	7.0	7.8	7.3	8.0
Other electrical equipment	361-64,369	2.0	2.2	2.6	2.3	2.3	2.2	2.2	2.1	2.3	2.1	2.5
Transportation equipment	37	3.4	3.6	3.4	3.5	3.5	3.4	4.0	4.2	3.9	3.7	3.6
Motor vehicles and motor vehicles equipment	371	3.1	3.3	3.4	3.4	3.7	3.7	4.1	4.0	3.7	3.4	3.6
Other transportation equipment	373-75,379	2.3	2.7	2.5	2.6	2.5	2.1	2.1	2.1	1.9	1.2	0.9
Aircraft and missiles	372,376	3.9	4.0	3.6	3.9	3.3	3.1	4.0	4.7	4.7	5.3	4.2
Professional and scientific instruments	38	8.3	8.2	7.5	7.1	6.8	7.1	7.1	7.2	7.2	6.5	7.3
Scientific and mechanical measuring instruments	381-82	8.4	8.4	8.1	7.6	6.9	6.9	6.3	6.2	6.4	5.8	6.6
Optical, surgical, photographic, and other instruments	384-87	8.1	8.0	7.2	7.1	7.1	7.5	8.0	8.2	7.9	7.2	8.0
Other manufacturing industries	27,31,39	1.0	1.2	1.1	1.0	0.9	0.9	0.8	1.3	1.3	1.1	1.2
Nonmanufacturing[a]		NA	NA	NA	NA	NA	NA	NA	NA	NA	2.2	2.4

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Appendix table 4-25.

Company and other (except federal) R&D funds as a percentage of net sales for industrial R&D performance, by industry and size of company: 1985–95

(Percentages)

Industry and size of company	SIC code	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Total[a]		NA	NA	NA	NA	NA	NA	NA	NA	NA	2.7	2.8
Fewer than 500 employees		3.4	4.0	3.8	3.7	3.5	3.3	3.2	3.2	3.6	2.5	3.9
500 to 999		2.2	2.2	2.2	1.7	1.7	1.7	2.4	2.7	2.7	2.5	3.0
1,000 to 4,999		2.4	2.4	2.4	2.3	2.1	1.9	2.4	2.7	2.5	2.5	2.6
5,000 to 9,999		1.8	2.0	2.0	2.0	2.1	2.8	2.9	2.8	2.8	2.2	2.0
10,000 to 24,999		2.5	2.6	2.5	2.6	2.5	2.5	3.0	2.6	2.5	2.5	2.0
25,000 or more		3.5	3.7	3.8	3.7	3.7	3.6	3.8	4.0	3.7	3.6	3.1

NA = not available; SIC = Standard Industrial Classification

NOTES: As a result of a new sample design, statistics for 1988-91 have been revised since originally published. These statistics now better reflect R&D performance among firms in the nonmanufacturing industries and small firms in all industries. As a result of the new sample design, data for 1991 and later years are not directly comparable with data for 1990 and earlier years.

[a] Beginning with data from the 1995 survey (in which 1994 data were also collected), this table includes both manufacturing and nonmanufacturing companies. Only manufacturing companies were included in prior years.

SOURCE: National Science Foundation, Science Resources Studies Division, *Research and Development in Industry: 1995* (Arlington, VA: 1998, forthcoming).

See figure 4-11 and text table 4-4

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Appendix table 4-26.

Trends in R&D and federal outlays: FYs 1980, 1990, and proposed 1998

Composition of federal outlays	1980	1990	1998
	Billions of current dollars		
Mandatory programs[a]	262.3	568.5	890.1
Net interest	52.5	184.2	249.9
Defense discretionary	134.6	300.1	260.1
R&D outlays	15.0	41.6	38.3
International discretionary	12.8	19.1	19.3
R&D outlays	0.1	0.4	0.3
Domestic discretionary	128.7	181.2	268.0
Nondefense R&D outlays	16.7	23.3	34.0
Total federal outlays	590.9	1,253.1	1,687.5
Total R&D	31.8	65.3	72.7
	Percentages		
Total R&D/total federal outlays	5.4	5.2	4.3
Nondefense R&D/total federal outlays	2.8	1.9	2.0
Total R&D/total discretionary	11.5	13.0	13.3
Nondefense R&D/domestic discretionary	13.0	12.9	12.7

[a] These include Social Security, Medicare, Medicaid, and other programs.

SOURCE: American Association for the Advancement of Science, *Research and Development: FY 1998* (Washington, DC: 1997).

See figure 4-12.

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Appendix table 4-27.

Federal obligations for R&D and R&D plant, by agency and character of work: FYs 1987-97

Agency	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
					Millions of current dollars						
TOTAL R&D											
Total, all agencies	55,254	56,769	61,407	63,560	61,295	65,593	67,314	67,256	68,755	69,077	68,064
Dept. of Agriculture	948	1,017	1,038	1,108	1,237	1,327	1,328	1,400	1,380	1,352	1,369
Dept. of Commerce	402	389	398	438	490	651	656	826	1,136	1,173	1,096
Dept. of Defense	35,232	35,249	37,577	37,268	32,135	36,130	35,849	34,566	34,362	34,284	32,964
Dept. of Education	133	141	159	170	171	169	178	177	178	182	188
Dept. of Energy	4,757	5,036	5,193	5,631	5,983	6,172	6,262	6,048	6,145	5,676	5,895
Dept. of Health & Human Services	6,606	7,158	7,903	8,406	9,756	8,988	10,349	11,022	11,455	11,914	12,185
Dept. of the Interior	404	417	469	509	593	609	619	694	562	565	574
Dept. of Justice	42	43	38	41	49	48	49	45	58	81	94
Dept. of Transportation	325	305	303	367	380	445	545	621	727	641	706
Dept. of the Treasury	27	26	26	26	31	25	17	19	61	64	64
Dept. of Veterans Affairs	210	215	235	238	217	224	236	248	238	276	258
Environmental Protection Agency	348	347	380	420	433	484	495	554	552	457	581
Agency for International Development	218	204	279	335	378	366	382	254	303	247	187
National Aeronautics & Space Administration	3,787	4,330	5,394	6,533	7,280	7,658	8,020	8,296	9,015	9,614	9,204
National Science Foundation	1,471	1,533	1,670	1,690	1,785	1,868	1,882	2,040	2,149	2,142	2,279
Nuclear Regulatory Commission	123	109	115	109	109	119	120	91	88	59	59
Smithsonian Institution	72	75	80	84	98	98	102	124	124	125	137
Tennessee Valley Authority	78	87	63	65	68	97	109	98	93	103	77
All other agencies	73	88	87	125	104	116	116	134	130	122	148
BASIC RESEARCH											
Total, all agencies	8,942	9,474	10,602	11,286	12,171	12,490	13,399	13,553	13,896	14,482	14,732
Dept. of Agriculture	446	481	485	519	558	595	616	606	595	586	608
Dept. of Commerce	26	31	29	31	34	35	37	40	39	38	39
Dept. of Defense	908	877	948	948	994	1,099	1,268	1,222	1,264	1,134	1,146
Dept. of Education	3	4	4	5	9	8	5	6	6	4	3
Dept. of Energy	1,069	1,185	1,411	1,505	1,687	1,736	1,755	1,603	1,634	1,957	2,035
Dept. of Health & Human Services	3,828	4,081	4,388	4,649	5,050	5,059	5,697	5,884	6,061	6,442	6,558
Dept. of the Interior	135	127	189	205	229	231	230	83	55	56	57
Dept. of Justice	8	8	7	9	6	5	5	6	8	8	12
Dept. of Transportation	0	0	0	0	0	1	2	3	47	46	54
Dept. of the Treasury	5	5	3	3	4	4	7	-	-	0	-
Dept. of Veterans Affairs	17	17	17	16	16	16	13	14	12	14	14
Environmental Protection Agency	31	27	51	74	91	110	89	101	70	66	75
Agency for International Development	3	3	3	5	6	6	8	2	2	2	5
National Aeronautics & Space Administration	1,014	1,113	1,417	1,637	1,706	1,738	1,800	1,964	1,978	2,009	1,885
National Science Foundation	1,371	1,433	1,563	1,586	1,676	1,742	1,744	1,871	1,973	1,968	2,090
Nuclear Regulatory Commission	0	0	0	0	0	0	0	0	0	0	0
Smithsonian Institution	72	75	80	84	98	98	102	124	124	125	137
Tennessee Valley Authority	4	3	3	5	2	2	10	9	9	12	0
All other agencies	5	4	4	4	5	6	11	14	17	16	15

Appendix table 4-27.

Federal obligations for R&D and R&D plant, by agency and character of work: FYs 1987-97

Agency	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
APPLIED RESEARCH											
Total, all agencies	8,998	9,177	10,164	10,337	11,798	12,001	13,491	13,888	14,678	14,096	14,441
Dept. of Agriculture	473	505	517	542	618	666	636	716	705	686	678
Dept. of Commerce	313	312	322	346	415	561	545	678	853	861	830
Dept. of Defense	2,440	2,362	2,708	2,582	2,724	2,975	3,515	3,040	3,070	2,814	2,716
Dept. of Education	104	107	118	125	123	120	128	131	133	138	140
Dept. of Energy	1,029	1,051	1,021	1,066	1,587	1,676	1,685	1,679	1,826	1,343	1,541
Dept. of Health & Human Services	2,194	2,416	2,700	2,818	3,112	2,887	3,496	3,853	4,015	4,083	4,210
Dept. of the Interior	247	266	253	270	324	340	350	567	477	484	489
Dept. of Justice	12	10	11	11	15	15	21	20	18	19	23
Dept. of Transportation	69	91	121	119	115	156	224	270	324	288	340
Dept. of the Treasury	13	11	13	15	21	17	5	9	49	50	54
Dept. of Veterans Affairs	173	179	197	199	178	185	194	209	206	239	223
Environmental Protection Agency	246	241	223	242	262	294	272	301	331	286	336
Agency for International Development	151	132	216	300	352	294	351	214	270	224	168
National Aeronautics & Space Administration	1,256	1,219	1,461	1,424	1,666	1,491	1,749	1,877	2,068	2,272	2,356
National Science Foundation	99	100	108	103	109	127	138	170	176	174	189
Nuclear Regulatory Commission	123	109	115	109	109	119	120	91	88	59	59
Smithsonian Institution	0	0	0	0	0	0	0	0	0	0	0
Tennessee Valley Authority	14	15	12	17	17	22	18	17	17	19	14
All other agencies	43	53	49	49	52	56	45	45	52	55	77
DEVELOPMENT											
Total, all agencies	37,313	38,119	40,641	41,937	37,327	41,102	40,424	39,815	40,181	40,499	38,890
Dept. of Agriculture	29	31	36	47	61	66	76	77	80	80	82
Dept. of Commerce	64	47	47	61	40	55	74	108	244	275	227
Dept. of Defense	31,884	32,010	33,921	33,739	28,417	32,056	31,066	30,304	30,028	30,336	29,103
Dept. of Education	26	30	37	40	39	42	44	40	39	40	45
Dept. of Energy	2,659	2,801	2,761	3,060	2,710	2,760	2,822	2,766	2,685	2,376	2,320
Dept. of Health & Human Services	584	661	814	939	1,594	1,042	1,157	1,285	1,379	1,390	1,417
Dept. of the Interior	22	24	27	33	40	39	39	44	29	26	27
Dept. of Justice	23	26	21	21	28	28	23	19	32	54	59
Dept. of Transportation	256	213	183	247	265	288	319	347	356	307	311
Dept. of the Treasury	10	10	9	7	7	4	6	10	12	13	11
Dept. of Veterans Affairs	19	19	21	22	23	23	29	25	19	22	22
Environmental Protection Agency	71	80	107	105	80	80	134	151	150	105	170
Agency for International Development	64	69	60	29	20	66	23	38	30	20	14
National Aeronautics & Space Administration	1,518	1,999	2,515	3,473	3,909	4,428	4,471	4,456	4,969	5,332	4,964
National Science Foundation	0	0	0	0	0	0	0	0	0	0	0
Nuclear Regulatory Commission	0	0	0	0	0	0	0	0	0	0	0
Smithsonian Institution	0	0	0	0	0	0	0	0	0	0	0
Tennessee Valley Authority	60	69	48	43	50	73	81	72	67	72	63
All other agencies	26	31	34	72	46	53	61	74	62	51	55

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Appendix table 4-27.

Federal obligations for R&D and R&D plant, by agency and character of work: FYs 1987-97

Agency	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
R&D PLANT											
Total, all agencies	1,846	2,057	2,165	2,272	2,853	2,985	3,101	2,171	2,257	1,971	2,085
Dept. of Agriculture	112	135	89	102	145	165	142	126	143	150	125
Dept. of Commerce	5	11	9	15	16	21	25	31	78	80	106
Dept. of Defense	477	436	499	487	426	397	372	222	65	85	40
Dept. of Education	21	5	2	9	4	2	2	2	2	0	0
Dept. of Energy	772	915	873	916	1,220	1,321	1,462	912	745	756	826
Dept. of Health & Human Services	37	20	79	108	86	97	149	120	256	304	429
Dept. of the Interior	12	9	11	14	22	18	23	9	7	2	7
Dept. of Justice	11	0	0	0	0	0	0	0	0	0	0
Dept. of Transportation	11	14	16	22	18	25	32	41	29	29	23
Dept. of the Treasury	0	0	0	0	0	0	0	0	0	0	0
Dept. of Veterans Affairs	6	20	11	3	3	6	3	12	7	4	4
Environmental Protection Agency	0	0	0	0	0	0	3	5	5	5	5
Agency for International Development	7	6	0	0	0	0	0	0	0	0	0
National Aeronautics & Space Administration	309	428	520	527	724	818	749	515	625	333	315
National Science Foundation	61	57	54	39	160	102	130	172	290	219	200
Nuclear Regulatory Commission	0	0	0	0	0	0	0	0	0	0	0
Smithsonian Institution	3	1	3	5	2	4	5	5	5	5	5
Tennessee Valley Authority	0	0	0	5	5	3	1	0	1	1	0
All other agencies	1	0	0	19	23	7	1	0	0	0	0
R&D AND R&D PLANT											
Total, all agencies	57,100	58,827	63,572	65,831	64,148	68,577	70,415	69,427	71,012	71,048	70,149
Dept. of Agriculture	1,060	1,152	1,128	1,211	1,381	1,492	1,470	1,525	1,523	1,502	1,494
Dept. of Commerce	408	400	407	454	505	672	682	857	1,214	1,252	1,201
Dept. of Defense	35,709	35,685	38,076	37,756	32,561	36,526	36,221	34,788	34,427	34,369	33,004
Dept. of Education	154	146	161	179	175	171	180	178	179	182	188
Dept. of Energy	5,529	5,951	6,066	6,547	7,203	7,493	7,724	6,960	6,890	6,432	6,721
Dept. of Health & Human Services	6,643	7,178	7,981	8,513	9,842	9,085	10,499	11,142	11,711	12,218	12,614
Dept. of the Interior	416	426	480	523	615	628	642	703	568	568	581
Dept. of Justice	54	43	38	41	49	48	49	45	58	81	94
Dept. of Transportation	336	319	319	388	398	470	578	662	756	671	728
Dept. of the Treasury	27	26	26	26	31	25	17	19	62	64	65
Dept. of Veterans Affairs	215	235	246	241	220	230	240	260	245	280	262
Environmental Protection Agency	348	347	380	420	433	484	498	558	556	462	586
Agency for International Development	224	211	279	335	378	366	382	254	303	247	187
National Aeronautics & Space Administration	4,097	4,759	5,913	7,060	8,004	8,475	8,769	8,812	9,640	9,946	9,519
National Science Foundation	1,532	1,590	1,724	1,729	1,945	1,970	2,012	2,212	2,439	2,361	2,479
Nuclear Regulatory Commission	123	109	115	109	109	119	120	91	88	59	59
Smithsonian Institution	74	76	84	89	100	102	107	129	129	130	142
Tennessee Valley Authority	78	88	63	70	73	101	110	98	94	104	77
All other agencies	74	88	87	144	127	122	117	134	130	122	148

Appendix table 4-27.

Federal obligations for R&D and R&D plant, by agency and character of work: FYs 1987-97

Agency	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
	Millions of constant 1992 dollars										
TOTAL R&D											
Total, all agencies	66,651	66,165	68,687	68,197	63,061	65,593	65,608	64,053	63,899	62,740	60,287
Dept. of Agriculture	1,143	1,185	1,161	1,189	1,272	1,327	1,294	1,333	1,282	1,228	1,212
Dept. of Commerce	485	453	445	470	504	651	640	787	1,056	1,065	971
Dept. of Defense	42,499	41,083	42,032	39,987	33,060	36,130	34,941	32,920	31,935	31,139	29,198
Dept. of Education	160	164	178	182	176	169	173	168	165	165	167
Dept. of Energy	5,738	5,870	5,808	6,041	6,155	6,172	6,103	5,760	5,711	5,155	5,222
Dept. of Health & Human Services	7,969	8,343	8,840	9,019	10,037	8,988	10,087	10,497	10,646	10,821	10,793
Dept. of the Interior	487	486	525	546	610	609	603	661	522	513	508
Dept. of Justice	51	50	43	43	50	48	48	43	54	73	83
Dept. of Transportation	392	355	339	393	391	445	531	591	676	583	625
Dept. of the Treasury	32	30	29	27	32	25	16	18	57	58	57
Dept. of Veterans Affairs	253	251	263	255	223	224	230	236	221	251	229
Environmental Protection Agency	420	405	425	450	445	484	483	527	513	415	515
Agency for International Development	262	238	312	359	389	366	373	242	281	224	165
National Aeronautics & Space Administration	4,568	5,047	6,033	7,010	7,490	7,658	7,817	7,901	8,378	8,732	8,153
National Science Foundation	1,774	1,786	1,868	1,813	1,837	1,868	1,834	1,943	1,997	1,945	2,019
Nuclear Regulatory Commission	148	126	128	117	112	119	117	86	82	54	52
Smithsonian Institution	86	88	90	90	101	98	99	118	115	114	121
Tennessee Valley Authority	94	102	70	70	70	97	106	93	87	94	68
All other agencies	88	103	98	134	107	116	113	128	121	111	131
BASIC RESEARCH											
Total, all agencies	10,787	11,041	11,859	12,109	12,521	12,490	13,060	12,908	12,914	13,154	13,049
Dept. of Agriculture	537	560	542	557	574	595	600	577	553	533	538
Dept. of Commerce	31	36	33	34	35	35	36	38	37	34	34
Dept. of Defense	1,095	1,022	1,060	1,017	1,023	1,099	1,236	1,164	1,175	1,030	1,015
Dept. of Education	4	5	5	5	9	8	5	5	5	3	3
Dept. of Energy	1,289	1,381	1,578	1,615	1,735	1,736	1,710	1,527	1,519	1,777	1,802
Dept. of Health & Human Services	4,617	4,757	4,908	4,988	5,196	5,059	5,552	5,604	5,633	5,851	5,809
Dept. of the Interior	163	147	211	220	236	231	224	79	51	51	50
Dept. of Justice	10	9	8	9	7	5	5	6	8	8	11
Dept. of Transportation	0	0	0	0	0	1	2	3	44	42	48
Dept. of the Treasury	6	6	4	4	4	4	6	0	0	0	0
Dept. of Veterans Affairs	21	20	19	17	17	16	13	14	12	13	12
Environmental Protection Agency	38	32	57	79	94	110	87	97	65	60	67
Agency for International Development	3	3	3	5	6	6	8	2	2	2	4
National Aeronautics & Space Administration	1,223	1,297	1,585	1,756	1,755	1,738	1,754	1,870	1,838	1,825	1,670
National Science Foundation	1,654	1,670	1,748	1,702	1,724	1,742	1,700	1,782	1,834	1,787	1,851
Nuclear Regulatory Commission	0	0	0	0	0	0	0	0	0	0	0
Smithsonian Institution	86	88	90	90	101	98	99	118	115	114	121
Tennessee Valley Authority	5	4	3	5	2	2	10	8	8	11	0
All other agencies	6	5	5	5	6	6	11	13	15	14	14

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Appendix table 4-27.

Federal obligations for R&D and R&D plant, by agency and character of work: FYs 1987-97

Agency	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
APPLIED RESEARCH											
Total, all agencies	10,854	10,695	11,369	11,091	12,137	12,001	13,150	13,226	13,641	12,803	12,791
Dept. of Agriculture	571	588	579	582	636	666	620	682	655	623	601
Dept. of Commerce	377	363	360	371	427	561	531	646	793	782	735
Dept. of Defense	2,943	2,753	3,029	2,770	2,802	2,975	3,426	2,895	2,853	2,556	2,405
Dept. of Education	125	124	131	134	127	120	125	125	123	126	124
Dept. of Energy	1,242	1,224	1,142	1,143	1,633	1,676	1,643	1,599	1,697	1,220	1,365
Dept. of Health & Human Services	2,647	2,815	3,021	3,024	3,202	2,887	3,407	3,669	3,731	3,709	3,729
Dept. of the Interior	298	310	283	289	333	340	341	540	444	439	433
Dept. of Justice	14	11	12	12	15	15	20	19	16	17	20
Dept. of Transportation	83	106	135	128	118	156	219	258	301	262	301
Dept. of the Treasury	15	13	15	16	21	17	4	9	45	46	48
Dept. of Veterans Affairs	209	208	220	214	183	185	189	199	192	217	197
Environmental Protection Agency	297	281	249	259	269	294	265	287	308	260	297
Agency for International Development	182	154	242	322	362	294	342	204	251	204	149
National Aeronautics & Space Administration	1,514	1,421	1,635	1,528	1,714	1,491	1,704	1,787	1,922	2,064	2,086
National Science Foundation	120	116	121	111	112	127	135	162	164	158	168
Nuclear Regulatory Commission	148	126	128	117	112	119	117	86	82	54	52
Smithsonian Institution	0	0	0	0	0	0	0	0	0	0	0
Tennessee Valley Authority	17	18	13	18	17	22	18	16	16	18	13
All other agencies	52	62	55	52	54	56	44	43	48	50	68
DEVELOPMENT											
Total, all agencies	45,010	44,428	45,460	44,997	38,402	41,102	39,399	37,919	37,343	36,784	34,447
Dept. of Agriculture	35	37	40	51	63	66	74	74	75	73	73
Dept. of Commerce	77	54	52	66	41	55	72	103	226	249	201
Dept. of Defense	38,461	37,307	37,943	36,201	29,235	32,056	30,278	28,861	27,907	27,553	25,778
Dept. of Education	31	35	42	43	41	42	43	38	37	36	40
Dept. of Energy	3,208	3,265	3,088	3,283	2,788	2,760	2,750	2,634	2,495	2,158	2,055
Dept. of Health & Human Services	705	771	911	1,007	1,639	1,042	1,127	1,224	1,282	1,262	1,255
Dept. of the Interior	26	28	30	36	41	39	38	42	27	23	24
Dept. of Justice	27	30	23	22	29	28	23	18	30	49	52
Dept. of Transportation	309	249	205	265	273	288	311	331	331	279	276
Dept. of the Treasury	11	12	10	7	7	4	5	9	12	12	9
Dept. of Veterans Affairs	23	22	23	24	23	23	28	23	18	20	19
Environmental Protection Agency	86	93	120	112	82	80	130	144	139	95	151
Agency for International Development	77	81	67	31	21	66	22	36	28	18	12
National Aeronautics & Space Administration	1,831	2,330	2,813	3,726	4,022	4,428	4,358	4,244	4,618	4,843	4,396
National Science Foundation	0	0	0	0	0	0	0	0	0	0	0
Nuclear Regulatory Commission	0	0	0	0	0	0	0	0	0	0	0
Smithsonian Institution	0	0	0	0	0	0	0	0	0	0	0
Tennessee Valley Authority	73	80	54	46	51	73	79	68	62	66	56
All other agencies	31	36	38	77	47	53	59	71	57	46	49

Appendix table 4-27.

Federal obligations for R&D and R&D plant, by agency and character of work: FYs 1987-97

Agency	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
R&D PLANT											
Total, all agencies	2,227	2,398	2,422	2,437	2,935	2,985	3,022	2,068	2,097	1,790	1,847
Dept. of Agriculture	135	158	100	110	149	165	139	120	133	136	111
Dept. of Commerce	6	13	10	17	16	21	25	30	72	72	93
Dept. of Defense	576	508	559	523	438	397	362	211	61	77	35
Dept. of Education	25	6	2	10	4	2	2	2	2	0	0
Dept. of Energy	931	1,066	977	983	1,255	1,321	1,424	868	692	686	732
Dept. of Health & Human Services	44	23	88	116	89	97	146	114	238	276	380
Dept. of the Interior	14	11	12	15	23	18	23	9	6	2	6
Dept. of Justice	13	0	0	0	0	0	0	0	0	0	0
Dept. of Transportation	14	16	17	23	19	25	31	39	27	26	20
Dept. of the Treasury	0	0	0	0	0	0	0	0	0	0	0
Dept. of Veterans Affairs	7	23	12	4	3	6	3	11	7	3	4
Environmental Protection Agency	0	0	0	0	0	0	2	5	4	4	4
Agency for International Development	8	7	0	0	0	0	0	0	0	0	0
National Aeronautics & Space Administration	373	499	581	565	744	818	730	491	581	302	279
National Science Foundation	74	66	60	42	164	102	127	164	269	199	177
Nuclear Regulatory Commission	0	0	0	0	0	0	0	0	0	0	0
Smithsonian Institution	3	1	4	5	2	4	5	5	5	5	4
Tennessee Valley Authority	0	0	0	5	5	3	1	0	1	1	0
All other agencies	1	0	0	20	23	7	1	0	0	0	0
R&D AND R&D PLANT											
Total, all agencies	68,878	68,562	71,109	70,634	65,996	68,577	68,630	66,121	65,996	64,530	62,133
Dept. of Agriculture	1,278	1,342	1,261	1,299	1,421	1,492	1,433	1,453	1,416	1,364	1,323
Dept. of Commerce	492	466	455	487	520	672	664	816	1,128	1,138	1,064
Dept. of Defense	43,074	41,590	42,591	40,510	33,498	36,526	35,303	33,131	31,996	31,216	29,233
Dept. of Education	185	170	180	192	180	171	175	170	167	165	167
Dept. of Energy	6,670	6,936	6,785	7,024	7,411	7,493	7,528	6,628	6,403	5,842	5,953
Dept. of Health & Human Services	8,013	8,366	8,928	9,135	10,126	9,085	10,232	10,611	10,884	11,097	11,173
Dept. of the Interior	501	497	537	561	633	628	626	670	528	515	514
Dept. of Justice	65	50	43	43	50	48	48	43	54	73	83
Dept. of Transportation	406	371	357	417	410	470	563	630	702	609	645
Dept. of the Treasury	33	31	29	28	32	25	16	18	57	58	57
Dept. of Veterans Affairs	260	274	275	259	226	230	233	247	228	254	232
Environmental Protection Agency	420	405	425	450	445	484	485	532	517	420	519
Agency for International Development	271	245	312	359	389	366	373	242	281	224	165
National Aeronautics & Space Administration	4,941	5,546	6,614	7,575	8,234	8,475	8,547	8,392	8,959	9,034	8,431

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Appendix table 4-27.

Federal obligations for R&D and R&D plant, by agency and character of work: FYs 1987-97

Agency	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
National Science Foundation	1,848	1,853	1,928	1,855	2,001	1,970	1,961	2,107	2,267	2,144	2,196
Nuclear Regulatory Commission	148	126	128	117	112	119	117	86	82	54	52
Smithsonian Institution	90	88	94	95	102	102	104	123	120	118	126
Tennessee Valley Authority	94	102	70	75	75	101	107	93	87	95	68
All other agencies	90	103	97	154	130	122	114	128	121	111	131

NOTE: See appendix table 4-1 for GDP implicit price deflators used to convert current dollars to constant 1992 dollars.

SOURCES: National Science Foundation, Science Resources Studies Division (NSF/SRS), *Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1956-1996*, NSF 96-320 (Arlington, VA : 1996); and NSF/SRS, *Federal Funds for Research and Development: Fiscal Years 1995, 1996, and 1997*, Detailed Statistical Tables, NSF 97-327 (Arlington, VA: 1997).

See figures 4-13 and 4-14 and text table 4-7.

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Appendix table 4-28.

Department of Defense basic research funding: FYs 1996-2001

(Millions of dollars)

	1996	1997	1998	1999	2000	2001
Total Department of Defense	1,126	1,156	1,218	1,270	1,317	1,361
Total, services	787	825	858	897	934	970
Army	186	204	215	224	236	246
In-house laboratory independent research	14	15	16	17	18	19
Defense research sciences	125	142	147	153	162	167
University and industry research centers	47	47	52	54	57	60
Navy	377	387	403	428	449	470
In-house laboratory independent research	15	15	17	17	17	18
Defense research sciences	362	372	386	411	432	452
Air Force (Defense research sciences)	224	234	240	245	249	254
Total, Defense agencies	339	331	360	373	383	391
Chemical and biological defense programs	27	29	26	27	28	29
Office of the Secretary of Defense	234	227	259	270	277	285
In-house laboratory independent research	3	2	1	1	0	0
University research initiatives	222	209	237	247	255	262
Focused research initiatives	9	16	21	22	22	23
Advanced Research Projects Agency (Defense research sciences)	78	75	75	76	78	77

SOURCE: Department of Defense, *Basic Research Plan* (Washington, DC: 1996).

Science & Engineering Indicators – 1998

Appendix table 4-29.

Estimated federal obligations for R&D, by selected agency, performer, and character of work: FY 1997

(Millions of current dollars)

Agency	Total	Federal intramural	Industrial firms	FFRDCs administered by industry	Universities and colleges	FFRDCs administered by U&C	Other nonprofit	FFRDCs administered by nonprofits	State and local govt.	Foreign
Total R&D										
Total, all agencies	68,064	16,404	30,713	1,340	12,362	3,231	2,884	644	282	206
Dept. of Agriculture	1,369	922	12	0	421	0	7	0	2	4
Dept. of Commerce	1,096	712	303	0	71	*	6	0	3	1
Dept. of Defense	32,964	7,919	22,625	155	1,288	203	351	363	0	61
Dept. of Energy	5,895	507	1,516	933	574	2,035	69	233	14	14
Dept. of Health & Human Services	12,185	2,362	557	227	7,088	21	1,734	21	129	46
Dept. of the Interior	574	508	16	*	48	*	*	0	*	1
Dept. of Transportation	706	239	264	2	67	9	27	7	91	*
Environmental Protection Agency	581	237	158	0	132	0	43	0	7	4
National Aeronautics & Space Admin	9,204	2,301	5,063	0	708	804	275	4	3	47
National Science Foundation	2,279	19	125	*	1,824	145	156	1	5	5
All other agencies	1,212	677	75	24	142	13	216	16	27	23
Basic research										
Total, all agencies	14,732	2,668	1,279	368	7,405	1,520	1,270	83	92	47
Dept. of Agriculture	608	395	7	0	199	0	4	0	1	2
Dept. of Commerce	39	34	1	0	4	*	*	0	0	0
Dept. of Defense	1,146	293	153	1	647	4	39	*	0	9
Dept. of Energy	2,035	69	103	241	440	1,096	14	70	2	1
Dept. of Health & Human Services	6,558	1,142	270	126	3,928	17	973	11	64	27
Dept. of the Interior	57	51	0	0	6	0	*	0	0	0
Dept. of Transportation	54	*	20	*	1	*	12	0	21	0
Environmental Protection Agency	75	31	20	0	17	0	6	0	1	*
National Aeronautics & Space Admin	1,885	471	614	0	480	257	56	1	1	3
National Science Foundation	2,090	18	90	*	1,680	145	149	*	3	4
All other agencies	186	164	0	0	4	0	17	1	1	1
Applied research										
Total, all agencies	14,441	5,028	3,521	637	3,418	611	930	109	115	73
Dept. of Agriculture	678	449	6	0	218	0	3	0	1	2
Dept. of Commerce	830	605	152	0	64	*	4	0	3	1
Dept. of Defense	2,716	1,073	1,192	8	321	65	39	14	0	5
Dept. of Energy	1,541	183	173	529	93	439	36	69	6	13
Dept. of Health & Human Services	4,210	1,047	222	76	2,204	3	579	9	56	14
Dept. of the Interior	489	441	6	*	41	*	*	0	*	1
Dept. of Transportation	340	148	110	1	29	2	14	1	36	*
Environmental Protection Agency	335	137	91	0	76	0	25	0	4	2
National Aeronautics & Space Admin	2,356	589	1,485	0	107	90	71	1	1	12
National Science Foundation	189	1	34	0	144	*	6	0	2	2
All other agencies	757	356	50	23	120	13	153	16	6	22

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Appendix table 4-29.

Estimated federal obligations for R&D, by selected agency, performer, and character of work: FY 1997

(Millions of current dollars)

Agency	Total	Federal intramural	Industrial firms	FFRDCs administered by industry	Universities and colleges	FFRDCs administered by U&C	Other nonprofit	FFRDCs administered by nonprofits	State and local govt.	Foreign
					Development					
Total, all agencies	38,890	8,708	25,913	334	1,539	1,099	684	453	75	87
Dept. of Agriculture	82	78	0	0	4	0	*	0	*	*
Dept. of Commerce	227	73	150	0	3	0	1	0	0	1
Dept. of Defense	29,103	6,553	21,280	146	320	134	274	349	0	48
Dept. of Energy	2,320	255	1,240	163	41	501	19	94	6	*
Dept. of Health & Human Services	1,417	173	65	25	955	1	182	1	10	4
Dept. of the Interior	27	16	10	0	1	0	0	0	0	0
Dept. of Transportation	311	91	134	1	37	6	1	6	35	*
Environmental Protection Agency	170	69	46	0	39	0	13	0	2	1
National Aeronautics & Space Admin	4,964	1,241	2,963	0	120	457	147	2	1	32
National Science Foundation	0	0	0	0	0	0	0	0	0	0
All other agencies	268	157	25	0	19	0	47	0	21	1

* = less than $500,000; FFRDCs = federally funded research and development centers; U&C = universities and colleges

NOTES: These figures reflect funding levels as reported by federal agencies in March through October 1996.

SOURCE: National Science Foundation, Science Resources Studies Division, *Federal Funds for Research and Development: Fiscal Years 1995, 1996, and 1997*, Detailed Statistical Tables, NSF 97-327 (Arlington, VA: 1997).

See text table 4-6.

Appendix table 4-30.

Federal obligations for R&D, by character of work and performer: FYs 1987-97

Character of work and performer	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996(est.)	1997(est.)
					Millions of current dollars						
Total R&D	55,253	56,769	61,406	63,667	61,295	65,592	67,314	67,256	68,755	69,077	68,064
Federal intramural[a]	13,413	14,115	15,121	16,002	15,238	15,690	16,556	16,139	17,343	16,897	16,404
Industrial firms excluding FFRDCs	26,768	26,719	28,548	29,378	26,421	29,745	30,326	30,454	30,469	31,268	30,713
FFRDCs administered by industry	1,860	1,911	1,960	2,237	2,068	2,010	1,451	1,294	1,204	1,231	1,340
Universities and colleges excluding FFRDCs	7,337	7,828	8,672	9,142	10,169	10,271	11,156	11,829	11,933	12,251	12,362
FFRDCs administered by universities	3,210	3,474	3,497	3,466	3,604	3,856	3,666	3,293	3,574	3,302	3,231
Nonprofit institutions excluding FFRDCs	1,711	1,683	1,999	2,249	2,637	2,804	2,811	2,930	2,807	2,867	2,884
FFRDCs administered by nonprofit institutions	511	506	522	632	679	746	753	736	831	721	644
State and local government	148	142	167	214	215	184	320	325	317	274	282
Foreign	296	392	919	345	264	288	272	257	278	266	206
Basic research	8,942	9,474	10,602	11,286	12,171	12,490	13,399	13,553	13,895	14,482	14,732
Federal intramural[a]	2,046	2,050	2,371	2,366	2,447	2,397	2,605	2,505	2,713	2,414	2,668
Industrial firms excluding FFRDCs	467	597	773	888	950	920	959	1,109	1,221	1,226	1,279
FFRDCs administered by industry	120	133	167	175	209	188	237	238	239	340	368
Universities and colleges excluding FFRDCs	4,666	4,868	5,221	5,548	6,065	6,332	6,799	7,024	6,951	7,754	7,405
FFRDCs administered by universities	907	990	1,098	1,228	1,306	1,394	1,438	1,336	1,438	1,504	1,520
Nonprofit institutions excluding FFRDCs	658	729	839	924	1,016	1,097	1,165	1,126	1,134	1,062	1,270
FFRDCs administered by nonprofit institutions	13	18	42	59	81	65	71	74	75	72	83
State and local government	38	43	44	50	49	42	72	75	79	70	92
Foreign	29	46	47	48	49	54	53	66	45	41	47
Applied research	8,998	9,176	10,163	10,453	11,798	12,001	13,491	13,887	14,678	14,096	14,441
Federal intramural[a]	3,392	3,288	3,611	3,587	4,093	4,219	4,755	4,983	5,075	4,990	5,028
Industrial firms excluding FFRDCs	1,982	2,046	2,102	2,312	2,457	2,531	3,060	2,954	3,507	3,447	3,521
FFRDCs administered by industry	314	322	353	367	416	405	559	500	579	538	637
Universities and colleges excluding FFRDCs	1,975	2,155	2,572	2,593	2,803	2,729	3,046	3,299	3,420	3,166	3,418
FFRDCs administered by universities	564	575	605	581	855	958	910	845	797	582	611
Nonprofit institutions excluding FFRDCs	550	571	681	738	910	952	876	969	922	1,039	930
FFRDCs administered by nonprofit institutions	77	65	67	89	90	74	102	104	135	112	109
State and local government	53	60	78	76	80	67	140	156	143	129	115
Foreign	93	94	95	109	94	66	44	77	100	93	73
Development	37,313	38,119	40,640	41,929	37,327	41,102	40,424	39,815	40,181	40,499	38,890
Federal intramural[a]	7,975	8,776	9,139	10,049	8,699	9,074	9,196	8,651	9,555	9,493	8,708
Industrial firms excluding FFRDCs	24,320	24,077	25,673	26,178	23,014	26,294	26,307	26,391	25,741	26,595	25,913
FFRDCs administered by industry	1,426	1,456	1,440	1,695	1,444	1,417	655	556	386	354	334
Universities and colleges excluding FFRDCs	697	805	879	1,001	1,301	1,211	1,312	1,505	1,561	1,331	1,539
FFRDCs administered by universities	1,739	1,909	1,794	1,658	1,443	1,504	1,319	1,112	1,339	1,216	1,099
Nonprofit institutions excluding FFRDCs	503	383	480	587	712	754	771	835	750	766	684
FFRDCs administered by nonprofit institutions	421	423	412	484	509	606	580	558	621	538	453
State and local government	58	39	46	88	86	75	108	95	95	75	75
Foreign	173	251	777	188	121	168	175	113	133	132	87

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Appendix table 4-30.

Federal obligations for R&D, by character of work and performer: FYs 1987-97

Character of work and performer	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996(est.)	1997(est.)
	Millions of constant 1992 dollars										
Total R&D	66,650	66,164	68,687	68,312	63,061	65,592	65,608	64,053	63,899	62,740	60,287
Federal intramural[a]	16,180	16,451	16,914	17,170	15,677	15,690	16,136	15,371	16,118	15,347	14,529
Industrial firms excluding FFRDCs	32,290	31,141	31,933	31,521	27,182	29,745	29,558	29,004	28,317	28,399	27,203
FFRDCs administered by industry	2,244	2,227	2,192	2,400	2,128	2,010	1,414	1,232	1,119	1,118	1,186
Universities and colleges excluding FFRDCs	8,850	9,124	9,700	9,809	10,462	10,271	10,873	11,265	11,090	11,127	10,950
FFRDCs administered by universities	3,872	4,049	3,912	3,719	3,708	3,856	3,573	3,136	3,322	2,999	2,861
Nonprofit institutions excluding FFRDCs	2,064	1,962	2,236	2,413	2,713	2,804	2,740	2,790	2,608	2,604	2,554
FFRDCs administered by nonprofit institutions	616	590	584	678	699	746	734	700	773	655	571
State and local government	179	166	187	230	221	184	312	310	294	249	249
Foreign	357	457	1,028	370	272	288	265	244	258	242	182
Basic research	10,786	11,042	11,859	12,109	12,522	12,490	13,059	12,907	12,914	13,154	13,049
Federal intramural[a]	2,468	2,389	2,652	2,539	2,517	2,397	2,539	2,386	2,521	2,192	2,363
Industrial firms excluding FFRDCs	563	696	865	953	977	920	935	1,056	1,135	1,113	1,133
FFRDCs administered by industry	145	155	187	188	215	188	231	226	222	309	326
Universities and colleges excluding FFRDCs	5,628	5,674	5,840	5,953	6,240	6,332	6,627	6,690	6,460	7,042	6,559
FFRDCs administered by universities	1,094	1,154	1,228	1,318	1,344	1,394	1,402	1,272	1,337	1,366	1,346
Nonprofit institutions excluding FFRDCs	793	850	938	991	1,045	1,097	1,135	1,072	1,054	965	1,125
FFRDCs administered by nonprofit institutions	16	21	47	63	83	65	69	70	70	65	73
State and local government	45	50	49	54	50	42	70	72	73	64	82
Foreign	35	54	53	52	50	54	52	63	41	38	41
Applied research	10,854	10,695	11,368	11,216	12,138	12,001	13,149	13,226	13,641	12,803	12,791
Federal intramural[a]	4,091	3,832	4,039	3,849	4,211	4,219	4,635	4,746	4,716	4,533	4,454
Industrial firms excluding FFRDCs	2,391	2,385	2,351	2,481	2,528	2,531	2,982	2,814	3,259	3,131	3,118
FFRDCs administered by industry	378	375	395	394	428	405	545	476	538	488	564
Universities and colleges excluding FFRDCs	2,382	2,512	2,877	2,782	2,884	2,729	2,969	3,142	3,179	2,876	3,027
FFRDCs administered by universities	681	670	677	623	880	958	887	805	741	529	542
Nonprofit institutions excluding FFRDCs	663	666	762	792	936	952	854	923	857	944	823
FFRDCs administered by nonprofit institutions	92	76	75	95	93	74	99	99	125	102	96
State and local government	64	70	87	82	82	67	136	148	133	117	102
Foreign	112	110	106	117	97	66	43	74	93	84	64
Development	45,009	44,428	45,459	44,988	38,402	41,102	39,400	37,919	37,343	36,784	34,447
Federal intramural[a]	9,620	10,228	10,223	10,782	8,950	9,074	8,963	8,239	8,880	8,622	7,713
Industrial firms excluding FFRDCs	29,337	28,062	28,717	28,088	23,677	26,294	25,640	25,134	23,923	24,155	22,952
FFRDCs administered by industry	1,721	1,697	1,611	1,819	1,486	1,417	638	530	359	321	296
Universities and colleges excluding FFRDCs	841	938	983	1,074	1,338	1,211	1,279	1,434	1,451	1,209	1,363
FFRDCs administered by universities	2,097	2,225	2,007	1,779	1,485	1,504	1,286	1,059	1,244	1,105	974
Nonprofit institutions excluding FFRDCs	607	446	537	630	733	754	751	795	697	695	606
FFRDCs administered by nonprofit institutions	508	493	461	519	524	606	565	531	577	488	401
State and local government	70	45	51	94	88	75	105	90	88	68	66
Foreign	209	293	869	202	124	168	171	108	124	120	77

Appendix table 4-30.

Federal obligations for R&D, by character of work and performer: FYs 1987-97

FFRDCs = federally funded research and development centers

NOTE: See appendix table 4-1 for GDP implicit price deflators used to convert current dollars to constant 1992 dollars.

[a]Federal intramural activities cover costs associated with the planning and administration of intramural and extramural programs by federal personnel and actual intramural performance.

SOURCES: National Science Foundation, Science Resources Studies Division (NSF/SRS), *Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1956-1996*, NSF 96-320 (Arlington, VA: 1996); and NSF/SRS, *Federal Funds for Research and Development: Fiscal Years 1995, 1996, and 1997*, Detailed Statistical Tables, NSF 97-327 (Arlington, VA: 1997).

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Appendix table 4-31.

Federal R&D obligations for federal intramural performance, by selected agency: FYs 1980-97

(Millions of current dollars)

	All agencies	Defense	Energy	NASA	HHS	USDA	Commerce	Interior	All other agencies
1980	7,632	3,796	474	965	820	457	226	242	653
1981	8,426	4,281	451	1,044	872	511	237	274	756
1982	9,141	5,139	176	1,166	946	531	242	261	680
1983	10,582	6,401	258	1,134	1,034	559	252	274	670
1984	11,572	7,257	216	1,043	1,066	589	256	334	811
1985	12,945	8,324	224	1,171	1,147	628	280	342	830
1986	13,535	8,881	206	1,217	1,236	630	285	332	749
1987	13,413	8,336	248	1,414	1,293	649	320	355	799
1988	14,115	8,880	245	1,335	1,408	694	316	353	883
1989	15,121	9,295	248	1,733	1,529	689	325	394	907
1990	16,003	9,639	307	1,968	1,662	737	336	424	929
1991	15,238	8,157	381	2,112	1,975	824	400	490	900
1992	15,690	8,601	336	2,210	1,783	862	512	513	872
1993	16,556	8,742	517	2,295	2,033	868	500	522	1,080
1994	16,139	8,017	562	2,271	2,206	931	597	595	959
1995	17,343	8,907	491	2,254	2,485	915	665	492	1,135
1996 (est.)	16,897	8,655	416	2,403	2,240	898	688	493	1,104
1997 (est.)	16,404	7,919	507	2,301	2,362	922	712	508	1.172

HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; USDA = Department of Agriculture

NOTE: Intramural activities cover costs associated with the planning and administration of intramural and extramural R&D programs by federal personnel and actual intramural R&D performance.

SOURCES: National Science Foundation, Science Resources Studies Division (NSF/SRS), *Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1956-1996*, NSF 96-320 (Arlington, VA: 1996); and NSF/SRS, *Federal Funds for Research and Development: Fiscal Years 1995, 1996, and 1997*, Detailed Statistical Tables, NSF 97-327 (Arlington, VA: 1997).

See text table 4-7.

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Appendix table 4-32.

Federal R&D laboratory campuses, by agency and state: FY 1995

Federal agency	Number of laboratory campuses	1995 (millions)
Total	515	26,578.8
Department of Agriculture	185	733.4
Agricultural Research Service	107	556.1
Forest Service	78	177.3
Department of Commerce	38	430.3
Nat. Inst. of Standards & Tech.	2	199.9
Nat. Oceanic & Atmos. Admin.	36	230.4
Department of Defense	68	9,150.8
Dept. of the Air Force	11	1,824.0
Dept. of the Army	29	2,076.3
Dept. of the Navy	21	4,668.2
Other Defense agencies	7	582.3
Department of Education	10	41.0
Department of Energy	33	8,080.7
Defense Programs	3	3,203.3
Energy research	16	2,670.6
Energy efficiency & renewable	1	237.6
Environmental management	3	904.0
Fossil energy	6	445.7
Naval reactors	2	585.0
Nonproliferation	1	5.0
Office of the Sec. of Energy	1	29.5
Dept. of Health & Human Services	19	1,371.4
Centers for Disease Ctrl. & Prev.	6	108.6
Food and Drug Administration[a]	3	40.2
National Institutes of Health	10	1,222.6
Department of the Interior	20	547.4
Bureau of Reclamation	1	71.3
National Biological Service	16	105.1
U.S. Geological Survey	3	371.0
Department of Justice—DEA	2	1.0
Department of Transportation	6	536.2
Federal Aviation Administration	3	211.7
Federal Highway Administration	1	125.5
Nat. Highway Traf. Safety Admin.	1	0.8
Research & Spec Prog Admin.	1	198.2
Department of the Treasury—IRS	1	1.5
Department of Veterans Affairs	102	270.0
Environ. Protection Agency (R&D)	11	348.2
Nat. Aeronautics & Space Admin.	10	4,832.7
Aeronautics	4	1,369.7
Mission to Planet Earth	1	646.5
Space flight	4	2,032.8
Space science	1	783.7
National Science Foundation	5	173.4
Nuclear Regulatory Commission	1	16.0
Smithsonian Institution	2	17.5
Tennessee Valley Authority	2	27.3

State	Number of laboratory campuses	1995 (millions)
Total	515	26,578.8
Alabama	11	992.3
Alaska	10	33.8
Arizona	8	125.2
Arkansas	7	32.1
California	46	4,119.7
Colorado	13	575.3
Connecticut	5	18.6
Delaware	1	1.0
Florida	21	848.6
Georgia	14	132.8
Hawaii	6	21.2
Idaho	8	816.9
Illinois	15	727.7
Indiana	3	11.3
Iowa	4	64.8
Kansas	3	6.8
Kentucky	2	2.6
Louisiana	8	39.8
Maine	1	0.4
Maryland	25	2,921.2
Massachusetts	15	1,005.3
Michigan	8	101.8
Minnesota	7	33.9
Mississippi	13	285.1
Missouri	8	71.4
Montana	6	21.0
Nebraska	4	19.9
Nevada	3	28.4
New Hampshire	3	31.4
New Jersey	8	592.1
New Mexico	9	2,692.5
New York	19	680.1
North Carolina	13	240.4
North Dakota	5	24.6
Ohio	12	705.2
Oklahoma	10	142.3
Oregon	14	83.3
Pennsylvania	14	578.7
Rhode Island	5	416.3
South Carolina	10	122.2
South Dakota	2	2.2
Tennessee	8	844.9
Texas	22	910.6
Utah	7	75.2
Vermont	2	3.8
Virginia	19	3,964.4
Washington	19	617.9
West Virginia	9	228.0
Wisconsin	9	42.0
Wyoming	3	4.7
Washington, D.C.	9	487.3
Puerto Rico	4	15.8
Foreign countries[b]	5	14.0

DEA = Drug Enforcement Administration; IRS = Internal Revenue Service

NOTES: Data for the Department of Defense and the National Aeronautics and Space Administration are from their FY 1994 operating budgets; data for the Department of Education are from its FY 1996 operating budget.

[a] Data for the Food and Drug Administration exclude product testing activities.

[b] The Agricultural Research Service has R&D laboratories in Argentina, France, and Panama. The Navy has medical labs in Egypt and Indonesia.

SOURCE: U.S. General Accounting Office, *Federal R&D Laboratories*, GAO/RCED/NSIAD-96-78R (Washington, DC: 1996).

Appendix table 4-33.

Federal R&D obligations to FFRDCs, by administering sector and selected agency: FYs 1987-97

(Millions of current dollars)

	All agencies	Defense	Energy	NASA	All other agencies
		Total			
1987	5,580	1,462	3,410	476	233
1988	5,891	1,541	3,572	560	217
1989	6,075	1,386	3,728	633	328
1990	6,425	1,494	3,895	622	415
1991	6,451	1,396	3,948	738	369
1992	6,718	1,537	3,996	793	392
1993	5,871	1,239	3,521	688	424
1994	5,322	856	3,310	778	378
1995	5,610	823	3,296	1,048	443
1996 (est.)	5,255	749	3,131	907	468
1997 (est.)	5,214	721	3,201	808	485
		FFRDCs administered by industry			
1987	1,860	325	1,475	0	61
1988	1,911	316	1,536	0	60
1989	2,056	309	1,588	0	160
1990	2,327	419	1,718	0	190
1991	2,168	316	1,690	0	162
1992	2,117	335	1,607	0	175
1993	1,451	202	1,094	0	156
1994	1,294	116	1,011	0	167
1995	1,204	93	936	0	175
1996 (est.)	1,231	76	905	0	250
1997 (est.)	1,340	155	933	0	252
		FFRDCs administered by universities and colleges			
1987	3,210	737	1,839	475	158
1988	3,474	829	1,945	560	141
1989	3,497	686	2,033	630	148
1990	3,466	658	2,020	619	168
1991	3,604	637	2,072	736	159
1992	3,856	668	2,227	791	169
1993	3,667	545	2,205	685	232
1994	3,293	275	2,077	771	170
1995	3,574	262	2,057	1,044	212
1996 (est.)	3,302	223	2,002	903	174
1997 (est.)	3,231	203	2,035	804	189
		FFRDCs administered by other nonprofit institutions			
1987	511	400	96	1	14
1988	506	397	91	1	16
1989	522	391	107	3	20
1990	632	416	157	2	57
1991	679	442	186	2	49
1992	746	534	163	2	47
1993	753	492	222	2	37
1994	736	466	222	7	41
1995	831	468	303	4	57
1996 (est.)	721	449	224	4	44
1997 (est.)	644	363	233	4	45

FFRDCs = federally funded research and development centers; NASA = National Aeronautics and Space Administration

SOURCES: National Science Foundation, Science Resources Studies Division (NSF/SRS), *Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1956-1996*, NSF 96-320 (Arlington, VA: 1996); NSF/SRS, *Federal Funds for Research and Development: Fiscal Years 1995, 1996, and 1997, Detailed Statistical Tables*, NSF 97-327 (Arlington, VA: 1997); and unpublished tabulations.

See text table 4-7.

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Appendix table 4-34.

Federal obligations for R&D to federally funded research and development centers, by individual FFRDC and agency: FY 1995

(Thousands of dollars)

FFRDC	Total	Commerce	Defense	Energy	HHS	NASA	NSF	Other agencies
TOTAL, ALL FFRDCs	5,609,641	129	823,106	3,295,890	186,057	1,047,684	141,476	115,299
FFRDCs administered by industrial firms	1,203,899	0	93,468	935,637	142,164	0	10	32,620
Energy Technology Engineering Center	11,783	0	48	11,526	0	0	0	209
Idaho National Engineering Laboratory	77,745	0	1,578	63,753	0	0	0	12,414
NCI Frederick Cancer R&D Center	141,707	0	72	0	141,635	0	0	0
Oak Ridge National Laboratory	288,332	0	9,086	267,663	529	0	10	11,044
Sandia National Laboratories	654,472	0	82,659	562,860	0	0	0	8,953
Savannah River Technology Center	29,860	0	25	29,835	0	0	0	0
FFRDCs administered by universities & colleges	3,574,349	129	261,520	2,057,324	24,478	1,043,913	140,883	46,102
Ames Laboratory	29,815	0	30	25,930	0	0	0	3,855
Argonne National Laboratory	252,879	4	1,841	246,877	0	240	0	3,917
Brookhaven National Laboratory	216,094	50	2,696	199,269	2,806	353	1,448	9,472
Ernest Orlando Lawrence Berkeley National Laboratory	170,870	75	879	156,754	12,343	703	116	0
Fermi National Accelerator Laboratory	170,917	0	0	170,917	0	0	0	0
Jet Propulsion Laboratory	1,056,916	0	25,778	0	0	1,031,078	60	0
Lawrence Livermore National Laboratory	500,622	0	32,857	461,840	3,192	1,016	2	1,715
Lincoln Laboratory	158,648	0	150,206	0	0	343	0	8,099
Los Alamos National Laboratory	540,637	0	24,781	489,485	5,537	812	1162	18,860
National Astronomy & Ionosphere Center	7,669	0	0	0	0	0	7,669	0
National Center for Atmospheric Research	79,483	0	462	0	0	7,449	71,572	0
National Optical Astronomy Observatories	29,099	0	0	0	0	0	29,099	0
National Radio Astronomy Observatory	29,960	0	0	0	363	0	29,597	0
Oak Ridge Institute for Science & Education	16,747	0	25	14,330	237	1,919	52	184
Princeton Plasma Physics Laboratory	115,284	0	0	115,178	0	0	106	0
Software Engineering Institute	21,965	0	21,965	0	0	0	0	0
Stanford Linear Accelerator Center	117,713	0	0	117,713	0	0	0	0
Thomas Jefferson National Accelerator Facility	59,031	0	0	59,031	0	0	0	0
FFRDCs administered by other nonprofit institutions	831,393	0	468,118	302,929	19,415	3,771	583	36,577
Aerospace FFRDC	137,495	0	136,552	0	0	738	205	0
Arroyo Center	2,621	0	2,621	0	0	0	0	0
C3I Federally Funded Research & Development Center	192,993	0	190,330	0	0	2,549	114	0
Center for Advanced Aviation System Development	15,961	0	7,073	0	0	0	0	8,888
Center for Naval Analyses	44,143	0	44,056	0	0	0	87	0
Center for Nuclear Waste Regulatory Analyses	5,795	0	0	0	0	0	0	5,795
Critical Technologies Institute	600	0	600	0	0	0	0	0
Inhalation Toxicology Research Institution	7,417	0	0	6,648	769	0	0	0
Institute for Defense Analyses Studies & Analyses FFRDC	56,215	0	56,038	0	0	0	177	0
Logistics Management Institute	2,271	0	1,871	0	0	200	0	200

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Appendix table 4-34.

Federal obligations for R&D to federally funded research and development centers, by individual FFRDC and agency: FY 1995

(Thousands of dollars)

FFRDC	Total	Commerce	Defense	Energy	HHS	NASA	NSF	Other agencies
National Defense Research Institute	14,326	0	2,633	0	11,558	135	0	0
National Renewable Energy Laboratory	102,278	0	0	102,278	0	0	0	0
Pacific Northwest National Laboratory	208,529	0	2,944	194,003	7,088	0	0	4,494
Project Air Force	24,149	0	24,000	0	0	149	0	0
Tax Systems Modernization Institute	17,200	0	0	0	0	0	0	17,200

FFRDC = federally funded research and development center; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation

SOURCE: National Science Foundation, Science Resources Studies Division, *Federal Funds for Research and Development: Fiscal Years 1995, 1996, and 1997*, Detailed Statistical Tables, NSF 97-327 (Arlington, VA: 1997).

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Appendix table 4-35.

Federal obligations for R&D to federally funded research and development centers, by individual FFRDC: FYs 1987-95

(Thousands of dollars)

FFRDC	1987	1988	1989	1990	1991	1992	1993	1994	1995
TOTAL, ALL FFRDCs	5,580,231	5,890,825	6,075,331	6,398,286	6,451,491	6,610,876	5,871,234	5,321,939	5,609,641
FFRDCs administered by industrial firms	1,859,963	1,911,314	2,056,329	2,326,808	2,168,256	2,009,767	1,451,325	1,293,494	1,203,899
Bettis Atomic Power Laboratory[a]	383,460	350,859	358,097	331,506	334,486	318,395	0	0	0
Energy Technology Engineering Center	20,284	14,746	10,470	9,364	16,270	13,231	14,288	1,010	11,783
Hanford Engineering Development Laboratory[a]	98,289	94,020	93,045	98,048	13,722	9,765	0	0	0
Idaho National Engineering Laboratory	117,743	104,112	120,067	173,209	175,143	134,220	68,452	85,853	77,745
Knolls Atomic Power Laboratory[a]	245,258	291,615	311,642	290,513	317,818	361,461	0	0	0
NCI Frederick Cancer R&D Center	6,854	13,600	110,285	143,961	114,380	16,430	107,112	127,181	141,707
Oak Ridge National Laboratory	236,553	249,570	277,707	422,146	292,433	291,305	319,357	288,824	288,332
Sandia National Laboratories	703,904	732,811	670,551	704,925	736,940	801,367	883,304	730,311	654,472
Savannah River Technology Center	47,618	59,981	104,465	153,136	167,064	63,593	58,812	60,315	29,860
FFRDCs administered by universities & colleges	3,209,624	3,473,924	3,497,050	3,449,838	3,603,818	3,855,467	3,666,498	3,292,933	3,574,349
Ames Laboratory	15,812	17,657	17,588	19,527	26,906	24,808	26,992	27,796	29,815
Argonne National Laboratory	187,063	200,871	211,732	249,181	254,080	256,434	273,859	258,533	252,879
Brookhaven National Laboratory	180,802	195,112	214,837	202,992	222,755	217,953	212,759	218,792	216,094
Ernest Orlando Lawrence Berkeley National Laboratory	120,459	122,226	142,641	240,242	146,705	160,124	169,294	174,136	170,870
Fermi National Accelerator Laboratory	136,650	145,475	160,462	157,947	158,883	166,220	168,117	168,684	170,917
Institute for Advanced Technology	0	0	0	1,579	2,548	7,078	13,873	0	0
Jet Propulsion Laboratory	483,964	678,811	771,362	698,709	797,629	963,504	741,535	785,880	1,056,916
Lawrence Livermore National Laboratory	877,401	905,311	779,275	652,888	815,470	802,136	705,261	526,388	500,622
Lincoln Laboratory	261,262	223,643	207,930	210,322	199,104	190,266	291,842	136,058	158,648
Los Alamos National Laboratory	645,046	665,812	655,138	627,304	603,461	623,077	637,417	552,389	540,637
National Astronomy & Ionosphere Center	5,814	6,752	6,187	7,337	6,051	7,347	7,766	10,035	7,669
National Center for Atmospheric Research	42,165	40,824	46,560	46,200	49,315	54,564	55,897	59,527	79,483
National Optical Astronomy Observatories	23,958	23,005	24,028	24,413	25,740	28,510	27,545	28,271	29,099
National Radio Astronomy Observatory	16,375	17,300	18,457	28,516	30,636	35,315	29,215	29,218	29,960
Oak Ridge Institute for Science & Education	11,561	13,539	12,600	26,550	15,942	21,716	16,993	24,082	16,747
Princeton Plasma Physics Laboratory	89,938	89,717	90,066	89,487	87,713	109,719	106,097	102,109	115,284
Software Engineering Institute	13,992	18,937	17,870	33,674	22,396	29,025	21,688	25,247	21,965
Stanford Linear Accelerator Center	90,312	99,707	109,500	115,491	115,118	134,074	131,568	121,429	117,713
Thomas Jefferson National Accelerator Facility	7,050	9,225	10,817	17,479	23,366	23,597	28,780	44,359	59,031
FFRDCs administered by other nonprofit institutions	510,644	505,587	521,952	621,640	679,417	745,642	753,411	735,512	831,393
Aerospace FFRDC	97,792	71,232	67,832	115,547	97,701	223,686	153,102	144,900	137,495
Arroyo Center	0	0	0	356	22,789	18,131	15,140	1,765	2,621
C3I Federal Contract Research Center	192,651	234,259	227,152	163,641	183,220	156,896	188,068	189,967	192,993
Center for Advanced Aviation System Development	0	0	0	21,863	17,813	35,410	36,300	17,498	15,961
Center for Naval Analyses	34,316	34,990	34,694	38,046	48,121	42,493	45,464	46,733	44,143
Center for Nuclear Waste Regulatory Analyses	0	0	1,625	2,635	3,287	3,040	4,983	5,234	5,795
Critical Technologies Institute	0	0	0	0	0	0	600	0	0
Inhalation Toxicology Research Institute	0	0	8,210	7,704	7,524	7,516	8,052	7,341	7,417

Appendix table 4-35.

Federal obligations for R&D to federally funded research and development centers, by individual FFRDC: FYs 1987-95

(Thousands of dollars)

FFRDC	1987	1988	1989	1990	1991	1992	1993	1994	1995
Institute for Defense Analyses Studies & Analyses FFRDC	27,691	33,326	41,124	54,828	44,229	49,378	48,575	46,731	56,215
Logistics Management Institute	1,608	2,013	1,145	36,328	3,341	2,045	3,928	3,122	2,271
National Defense Research Institute	17,152	15,819	21,427	7,375	25,849	23,634	8,396	17,833	14,326
National Renewable Energy Research Laboratory[b]	52,401	47,632	50,889	60,849	72,558	77,847	111,304	81,948	102,278
Pacific Northwest Laboratories	66,734	66,316	67,622	112,373	130,585	105,566	125,659	148,440	208,529
Project Air Force	20,299	0	232	95	22,400	0	1,685	24,000	24,149
Tax Systems Modernization Institute	0	0	0	0	0	0	2,155	2,155	17,200

FFRDC = federally funded research and development center

[a] The Department of Energy decertified Bettis Atomic Power Laboratory, Hanford Engineering Development Laboratory, and Knolls Atomic Power Laboratory as FFRDCs in October/November 1992.

[b] In September 1991, the name was changed from Solar Energy Research Institute.

SOURCES: National Science Foundation, Science Resources Studies Division, *Federal Funds for Research and Development: Fiscal Years 1995, 1996, and 1997*, Detailed Statistical Tables, NSF 97-327 (Arlington, VA: 1997); and unpublished tabulations.

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Appendix table 4-36.
Advanced Technology Program awards: 1990-96

	1990	1991	1992	1993	1994	1995	1996	Total
Number of awards	11	28	21	29	88	103	8	288
Single applicants	6	18	18	24	50	62	6	184
Joint ventures	5	10	3	5	38	41	2	104
Total participants[a]	35	83	32	50	211	318	12	741
Resubmittals	NA	3	7	6	4	17	2	39
Funding ($ millions)	96	202	97	118	640	827	37	2,019
ATP share	46	93	48	60	309	414	19	989
To joint ventures	38	65	19	19	216	304	9	670
To single applicants	8	28	29	41	93	110	10	319
Industry share	52	109	49	58	331	413	18	1,030
From joint ventures	45	83	19	20	233	340	10	750
From single applicants	7	26	30	38	98	73	8	280

ATP = Advanced Technology Program

NOTE: Funding of each award is the total in a period of two to six years.

[a] Total participants include single applicants, joint venture leads, and joint venture participants. This category excludes subcontractors, informal collaborators with joint ventures, and collaborators and strategic partners of single applicants.

SOURCE: U.S. Department of Commerce, Advanced Technology Program, unpublished tabulations.

See figure 4-17.

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Appendix table 4-37.

Small Business Innovation Research awards, by award type and agency: FYs 1983-95

(Millions of current dollars)

Award type and agency	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Cumu-lative 1983-95
Total[a]	45	108	199	298	351	389	432	461	483	508	698	718	865	5,555
By type														
Phase I awards	45	48	69	99	110	102	108	118	128	128	154	220	232	1,561
Phase II awards	0	60	130	199	241	285	322	342	336	371	491	474	602	3,853
By agency														
Defense	20	45	78	151	194	208	233	241	241	242	385	354	414	2,806
Health and Human Services	7	23	45	57	67	73	79	84	93	102	126	133	181	1,070
National Aeronautics and Space Administration	5	13	29	36	32	47	52	62	69	79	86	116	118	744
Energy	5	16	26	29	28	30	33	39	39	43	50	53	70	461
National Science Foundation	5	7	10	15	17	17	19	20	22	23	29	34	42	260
Agriculture	1	2	3	4	4	4	4	4	5	6	7	7	9	60
Transportation	*	2	3	4	3	3	4	4	6	3	4	7	10	53
Environmental Protection Agency	*	1	2	3	3	3	3	3	4	4	5	5	7	43
Education	*	1	1	2	2	2	2	2	3	2	3	3	3	26
Nuclear Regulatory Commission	*	1	1	1	1	1	1	1	0	1	2	1	2	13
Commerce	0	0	0	1	2	1	1	1	1	2	2	4	8	23
Interior	*	1	*	0	0	0	0	0	0	0	0	0	0	1

* = less than $500,000

[a] Totals are Small Business Innovation Research award obligations that include award modifications. The details by award type and agency do not necessarily contain subsequent year revisions and may not sum to totals.

SOURCE: U.S. Small Business Administration, *Small Business Innovation Development Act* (Washington, DC: annual series).

Science & Engineering Indicators – 1998

Appendix table 4-38.

Budgetary impact and company claims of the federal research and experimentation tax credit: FYs 1981-97

(Millions of dollars)

	Credits claimed by U.S. firms (current $)[a]	Outlay equivalent cost of credit (current $)[b]	Total federal R&D outlays	Ratio of credit outlays to R&D (%)	Credits claimed by U.S. firms (constant $)[a]	Outlay equivalent cost of credit (constant $)[b]
1981	639	205	32,459	0.63	981	315
1982	839	640	34,391	1.86	1,203	917
1983	1,278	1,010	36,659	2.76	1,751	1,384
1984	1,589	3,360	39,691	8.47	2,097	4,434
1985	1,628	2,430	44,171	5.50	2,076	3,099
1986	1,292	2,295	50,609	4.53	1,603	2,847
1987	1,053	2,715	51,612	5.26	1,270	3,274
1988	1,277	1,240	54,739	2.27	1,488	1,445
1989	1,341	1,590	59,450	2.67	1,499	1,778
1990	1,547	1,625	62,135	2.62	1,660	1,744
1991	1,585	1,070	61,130	1.75	1,631	1,101
1992	1,578	1,850	62,934	2.94	1,578	1,850
1993	NA	1,900	65,241	2.91	NA	1,851
1994	NA	2,110	66,159	3.19	NA	2,009
1995	NA	1,820	66,375	2.74	NA	1,691
1996	NA	1,245	66,877	1.86	NA	1,131
1997	NA	1,055	67,692	1.56	NA	934

NA = not available

NOTES: Tax expenditure estimates are prepared by the U.S. Treasury Department, based on the income tax law enacted as of December 31 of the year for which the expenditures are reported. Expenditures for the years 1996-97 are estimated based on the income tax law enacted as of December 31, 1996. See appendix table 4-1 for GDP implicit price deflators used to convert current dollars to constant 1992 dollars.

[a] The value of credits actually received by U.S. firms is less than the amounts claimed.

[b] "Outlay equivalent" estimates are comparable to taxable outlay figures reported in the budget. This allows for a comparison of the resource cost of the tax credit with the cost of direct federal R&D expenditure support.

SOURCES: U.S. Office of Management and Budget, *Budget of the United States Government* (Washington, DC: U.S. Government Printing Office, annual series); and U.S. Internal Revenue Service, as reported in Office of Technology Assessment, *The Effectiveness of Research and Experimentation Tax Credits*, OTA-BP-ITC-174 (Washington, DC: U.S. Government Printing Office, 1995).

See figure 4-30.

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Appendix table 4-39.

Federal R&D funding, by budget function: FYs 1980, 1985, and 1990-98

Function	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998
					Millions of current dollars						
Total	29,739	49,887	63,781	65,898	68,398	69,884	68,331	68,791	69,049	70,988	71,602
National defense	14,946	33,698	39,925	39,328	40,083	41,249	37,764	37,204	37,801	39,030	38,726
Nondefense	14,793	16,189	23,856	26,570	28,315	28,635	30,567	31,587	31,249	31,958	32,876
Health	3,694	5,418	8,308	9,226	10,055	10,280	10,993	11,407	11,867	12,693	12,998
Space research and technology	2,738	2,725	5,765	6,511	6,744	6,988	7,414	7,916	7,844	7,795	8,004
General science	1,233	1,862	2,410	2,635	2,659	2,691	2,712	2,794	2,846	2,962	3,086
Energy	3,603	2,389	2,726	2,953	3,153	2,677	2,873	2,844	2,521	2,259	2,229
Natural resources and environment	999	1,059	1,386	1,582	1,688	1,802	1,865	1,988	1,802	1,842	1,902
Transportation	887	1,030	1,045	1,231	1,523	1,703	1,888	1,833	1,795	1,827	1,939
Agriculture	585	836	950	1,052	1,155	1,152	1,193	1,194	1,176	1,185	1,196
Education, training, employment, and social services	468	220	374	433	365	348	373	369	331	370	411
International affairs	125	210	375	378	371	382	254	287	252	190	246
Veterans' benefits and services	126	193	216	219	245	250	265	257	259	267	239
Commerce and housing credit	101	114	140	178	192	220	380	525	432	435	498
Community and regional development	119	50	67	88	95	57	68	70	50	54	46
Administration of justice	45	47	44	51	51	49	46	59	56	67	70
Income security	47	21	33	30	37	36	45	43	16	10	10
General government	22	17	17	4	4	1	0	1	2	2	2
					Millions of constant 1992 dollars						
Total	50,150	63,631	68,435	67,796	68,398	68,113	65,077	63,932	62,716	62,877	61,726
National defense	25,204	42,982	42,838	40,461	40,083	40,204	35,966	34,576	34,333	34,570	33,384
Nondefense	24,946	20,649	25,597	27,335	28,315	27,909	29,111	29,356	28,382	28,306	28,341
Health	6,229	6,911	8,914	9,492	10,055	10,019	10,470	10,601	10,778	11,243	11,205
Space research and technology	4,617	3,476	6,186	6,699	6,744	6,811	7,061	7,357	7,124	6,904	6,900
General science	2,079	2,375	2,586	2,711	2,659	2,623	2,583	2,597	2,585	2,624	2,660
Energy	6,076	3,047	2,925	3,038	3,153	2,609	2,736	2,643	2,290	2,001	1,922
Natural resources and environment	1,685	1,351	1,487	1,628	1,688	1,756	1,776	1,848	1,637	1,632	1,640
Transportation	1,496	1,314	1,121	1,266	1,523	1,660	1,798	1,704	1,630	1,618	1,672
Agriculture	987	1,066	1,019	1,082	1,155	1,123	1,136	1,110	1,068	1,050	1,031
Education, training, employment, and social services	789	281	401	445	365	339	355	343	301	328	354
International affairs	211	268	402	389	371	372	242	267	229	168	212
Veterans' benefits and services	212	246	232	225	245	244	252	239	235	236	206
Commerce and housing credit	170	145	150	183	192	214	362	488	392	385	429
Community and regional development	201	64	72	91	95	56	65	65	45	48	40
Administration of justice	76	60	47	52	51	48	44	55	51	59	60
Income security	79	27	35	31	37	35	43	40	15	9	9
General government	37	22	18	4	4	1	0	1	2	2	2

NOTES: Data for 1980-96 are actual budget authority. Data for 1997 and 1998 are preliminary based on the FY 1998 budget. See appendix table 4-1 for GDP implicit price deflaters used to convert current dollars to constant 1992 dollars.

SOURCE: National Science Foundation, Science Resources Studies Division, *Federal R&D Funding by Budget Function: Fiscal Years 1996-98* (Arlington, VA: forthcoming).

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See figure 4-28.

Appendix table 4-40.
Federal basic research funding, by budget function: FYs 1980, 1985, and 1990-98

Function	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998
Millions of current dollars											
Total	4,716	7,810	11,288	12,405	12,973	13,440	13,552	13,772	14,443	14,853	15,296
Health	1,761	3,243	4,661	5,021	5,506	5,700	5,889	6,068	6,395	6,826	7,015
General science	1,152	1,779	2,306	2,526	2,532	2,553	2,542	2,622	2,662	2,773	2,886
Space research and technology	482	498	1,389	1,479	1,499	1,588	1,796	1,614	1,685	1,557	1,517
National defense	552	856	964	1,188	1,147	1,323	1,174	1,181	1,165	1,133	1,191
Energy	200	428	761	878	921	917	921	930	1,182	1,219	1,313
Agriculture	246	406	456	486	528	553	567	565	547	545	563
Natural resources and environment	136	206	336	389	383	376	224	187	147	149	157
Transportation	79	255	242	246	266	238	220	389	456	445	429
Education, training, employment, and social services	61	86	106	115	118	121	145	153	140	139	146
Commerce and housing credit	15	23	31	39	35	34	38	35	37	39	40
Veterans' benefits and services	14	15	16	16	16	16	16	16	13	14	14
Administration of justice	9	4	9	6	5	5	5	9	12	12	24
Community and regional development	8	6	3	10	11	10	9	3	0	0	0
General government	–	4	3	0	0	0	0	0	0	0	0
International affairs	0	4	4	6	6	8	6	0	2	2	1
Income security	1	0	0	0	0	0	0	0	0	0	0
Millions of constant 1992 dollars[a]											
Total	7,953	9,966	12,111	12,762	12,973	13,101	12,907	12,799	13,118	13,156	13,186
Health	2,970	4,136	5,001	5,166	5,506	5,556	5,609	5,639	5,808	6,046	6,047
General science	1,943	2,269	2,474	2,599	2,532	2,488	2,421	2,437	2,418	2,456	2,488
Space research and technology	813	635	1,490	1,522	1,499	1,548	1,710	1,500	1,530	1,379	1,308
National defense	931	1,092	1,034	1,222	1,147	1,289	1,118	1,098	1,058	1,004	1,027
Energy	337	546	817	903	921	894	877	864	1,074	1,080	1,132
Agriculture	415	518	489	500	528	539	540	525	497	483	485
Natural resources and environment	229	263	361	400	383	366	213	174	134	132	135
Transportation	133	325	260	253	266	232	210	362	414	394	370
Education, training, employment, and social services	103	110	114	118	118	118	138	142	127	123	126
Commerce and housing credit	25	29	33	40	35	33	36	33	34	35	34
Veterans' benefits and services	24	19	17	16	16	16	15	15	12	12	12
Administration of justice	15	5	10	6	5	5	5	8	11	11	21
Community and regional development	13	8	3	10	11	10	9	3	0	0	0
General government	–	5	3	0	0	0	0	0	0	0	0
International affairs	0	5	4	6	6	8	6	0	2	2	1
Income security	2	0	0	0	0	0	0	0	0	0	0

NOTE: Data for 1980-96 are actual budget authority. Data for 1997 and 1998 are preliminary based on the FY 1998 budget.

[a] See appendix table 4-1 for GDP implicit price deflaters used to convert current dollars to constant 1992 dollars.

SOURCE: National Science Foundation, Science Resources Studies Division, *Federal R&D Funding by Budget Function: Fiscal Years 1996-98* (Arlington, VA: forthcoming).

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Appendix table 4-41.

Distribution of government R&D budget appropriations, by socioeconomic objective: Most recent year
(Percentages)

Objective	United States (1996)	Japan (1996)	Germany (1995)	France (1996)	United Kingdom (1995)	Italy (1995)	Canada (1995)
Total (millions of U.S. $)[a]	69,049	15,068	15,285	13,255	8,184	6,478	3,264
Agriculture, forestry, and fishing	2.4	3.4	2.6	3.6	4.6	2.7	13.8
Industrial development	0.6	3.8	13.2	4.8	9.3	8.8	10.4
Energy	3.7	19.8	3.5	4.7	0.9	3.1	8.2
Infrastructure	2.7	2.0	1.6	0.5	1.8	0.5	5.1
Transport and telecommunications	2.6	1.7	0.5	NA	0.3	NA	3.9
Urban and rural planning	0.1	0.3	1.1	NA	1.5	NA	1.2
Environmental protection	0.7	0.6	3.5	2.0	2.1	2.4	2.5
Health	17.6	2.8	3.1	5.2	7.7	8.8	8.9
Social development and services	1.0	1.1	2.4	0.9	2.5	2.8	3.7
Earth and atmosphere	1.2	1.3	2.4	0.8	2.2	1.4	1.6
Advancement of knowledge	4.1	52.1	52.8	35.2	24.8	52.8	33.4
Advancement of research	4.1	11.1	14.6	19.2	6.1	8.0	14.1
General university funds	–	41.0	38.2	16.0	18.7	44.8	19.4
Civil space	11.4	7.0	5.1	10.9	2.9	8.7	7.5
Defense	54.7	6.2	9.1	29.0	40.8	4.7	4.8
Not elsewhere classified	0.0	0.0	0.7	2.5	0.4	3.3	0.0

NA = not separately available but included in subtotal; – = the United States does not have an equivalent to general university funds

NOTES: Percentages may not add to 100 because of rounding. U.S. data are based on budget authority. Because of general university funds and slight differences in accounting practices, the distribution of government budgets among socioeconomic objectives may not completely reflect the actual distribution of government-funded research in particular objectives. Japanese data are based on science and technology budget data, which include items other than R&D. Such items are a small proportion of the budget; therefore, the data may still be used as an approximate indicator of relative government emphasis on R&D by objective.

[a] Conversions of foreign currencies to U.S. dollars are calculated with purchasing power parity exchange rates. (See appendix table 4-2.)

SOURCES: National Science Foundation, Science Resources Studies Division, *Federal R&D Funding by Budget Function: Fiscal Years 1996-98* (Arlington, VA: forthcoming); and Organisation for Economic Co-operation and Development, Main Science and Technology Indicators database (Paris: August 1997).

See figure 4-26.

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Appendix table 4-42.

International R&D expenditures and R&D as a percentage of GDP: 1981-97

	United States	Japan	Germany[a]	France	United Kingdom	Italy	Canada
Total R&D expenditures in billions of constant 1992 U.S. dollars[b]							
1981	109.2	35.0	23.8	16.8	17.6	7.0	5.3
1982	114.9	37.6	24.5	18.0	NA	7.2	5.7
1983	122.6	40.5	25.0	18.5	17.0	7.7	5.8
1984	134.3	43.6	25.7	19.6	NA	8.4	6.3
1985	145.5	48.4	28.3	20.4	18.5	9.6	6.8
1986	148.8	49.1	29.2	20.7	19.4	9.9	7.2
1987	151.4	52.5	31.3	21.5	19.7	10.7	7.3
1988	155.0	56.7	32.4	22.5	20.3	11.4	7.4
1989	157.8	62.1	33.8	24.0	20.9	12.0	7.6
1990	162.0	67.2	34.1	25.4	21.3	12.8	8.0
1991	165.0	68.6	36.5	25.7	19.6	13.2	8.1
1992	164.9	69.6	37.2	26.5	20.7	13.6	8.4
1993	161.0	67.4	35.6	25.8	20.7	12.4	8.9
1994	160.5	66.4	35.5	25.2	20.7	11.8	9.2
1995	170.1	70.6	35.4	25.2	19.9	11.8	9.3
1996	175.6	NA	33.1	NA	NA	11.6	9.3
1997	182.2	NA	NA	NA	NA	NA	NA
R&D expenditures as a percentage of GDP							
1981	2.32	2.13	2.43	1.97	2.37	0.88	1.25
1982	2.49	2.22	2.52	2.06	NA	0.91	1.40
1983	2.55	2.35	2.52	2.11	2.19	0.95	1.37
1984	2.61	2.43	2.51	2.21	NA	1.01	1.41
1985	2.74	2.58	2.72	2.25	2.23	1.13	1.45
1986	2.71	2.55	2.73	2.23	2.25	1.13	1.49
1987	2.68	2.62	2.88	2.27	2.19	1.19	1.44
1988	2.64	2.66	2.86	2.28	2.14	1.22	1.39
1989	2.60	2.77	2.87	2.33	2.15	1.24	1.39
1990	2.64	2.85	2.75	2.41	2.18	1.30	1.47
1991	2.71	2.82	2.61	2.41	2.11	1.32	1.52
1992	2.64	2.76	2.48	2.42	2.13	1.31	1.57
1993	2.52	2.68	2.43	2.45	2.15	1.26	1.63
1994	2.43	2.64	2.33	2.38	2.11	1.16	1.62
1995	2.52	2.78	2.28	2.34	2.05	1.14	1.61
1996	2.55	NA	2.26	NA	NA	1.13	1.59
1997	2.59	NA	NA	NA	NA	NA	NA

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Appendix table 4-42.
International R&D expenditures and R&D as a percentage of GDP: 1981-97

	United States	Japan	Germany[a]	France	United Kingdom	Italy	Canada
Total R&D expenditures in billions of constant 1992 units of national currency[c]							
1981	109.2	6,678.0	52.2	110.0	11.0	10,469.1	6.7
1982	114.9	7,171.3	53.7	117.5	NA	10,841.8	7.3
1983	122.6	7,757.3	54.6	121.3	10.8	11,548.6	7.4
1984	134.3	8,335.2	55.9	128.2	NA	12,576.3	8.0
1985	145.5	9,249.3	61.7	133.4	11.6	14,388.2	8.7
1986	148.8	9,406.9	63.4	135.4	12.2	14,887.0	9.2
1987	151.4	10,055.2	67.8	140.9	12.4	16,103.5	9.3
1988	155.0	10,825.8	70.0	147.2	12.8	17,124.5	9.4
1989	157.8	11,832.1	72.8	156.4	13.1	17,954.5	9.6
1990	162.0	12,820.3	73.7	165.9	13.4	19,161.9	10.2
1991	165.0	13,146.5	78.6	166.7	12.7	19,760.0	10.3
1992	164.9	13,001.1	76.4	169.4	12.7	19,660.7	10.7
1993	161.0	12,655.4	73.9	169.6	13.1	18,698.4	11.4
1994	160.5	12,510.7	72.8	168.5	13.4	17,608.1	11.8
1995	170.1	13,303.9	72.6	169.4	13.3	17,787.7	12.0
1996	175.6	NA	72.7	NA	NA	17,776.9	12.0

NA = not available

[a] German data before 1991 are for West Germany only.

[b] Conversions of foreign currencies to U.S. dollars are calculated with purchasing power parity exchange rates. Constant 1992 dollars are based on U.S. GDP implicit price deflators. (See appendix tables 4-1 and 4-2.)

[c] Constant foreign currencies are based on deflation with each countries' GDP implicit price deflators.

SOURCES: National Science Foundation, Science Resources Studies Division, *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>; and Organisation for Economic Co-operation and Development, Main Science and Technology Indicators database (Paris: August 1997).

See figures 4-18, 4-19, 4-20, and 4-21.

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Appendix table 4-43.
R&D as a percentage of GDP in selected former communist countries: 1990-95
(Percentages)

	Russian Federation	Czech Republic	Hungary	Poland
1990	2.03	NA	NA	NA
1991	1.43	2.12	1.07	NA
1992	0.74	1.83	1.05	NA
1993	0.77	1.35	0.98	NA
1994	0.84	1.25	0.89	0.82
1995	0.73	1.15	0.75	0.74

NA = not available

SOURCES: Organisation for Economic Co-operation and Development, Main Science and Technology Indicators database (Paris: August 1997); and Centre for Science Research and Statistics, *Russian Science and Technology at a Glance: 1996* (Moscow: 1997).

See figure 4-22.

Science & Engineering Indicators – 1998

Appendix table 4-44.

International nondefense R&D expenditures and R&D as a percentage of GDP: 1981-97

	United States	Japan	Germany[a]	France	United Kingdom	Italy	Canada
Total nondefense R&D expenditures in billions of constant 1992 U.S. dollars[b]							
1981	81.4	34.8	23.0	13.4	13.7	6.8	5.1
1982	82.6	37.4	23.7	14.5	NA	7.1	5.6
1983	86.3	40.3	24.0	15.2	13.1	7.4	5.6
1984	93.9	43.3	24.7	16.1	NA	8.0	6.1
1985	100.4	48.0	27.1	16.9	14.6	9.1	6.6
1986	101.9	48.8	28.0	17.0	15.6	9.4	7.0
1987	103.3	52.1	29.9	17.5	16.2	10.3	7.0
1988	107.8	56.2	31.0	18.3	17.1	10.8	7.1
1989	113.8	61.6	32.4	19.7	17.6	11.4	7.3
1990	120.9	66.6	32.6	20.5	18.0	12.4	7.7
1991	127.8	67.9	35.0	21.1	16.6	12.7	7.9
1992	129.4	68.9	35.8	22.4	17.8	13.1	NA
1993	126.3	66.5	34.5	22.0	17.8	11.9	8.7
1994	128.6	65.6	34.3	21.7	18.0	11.3	NA
1995	138.3	69.7	34.2	NA	17.2	11.5	9.1
1996	144.4	NA	NA	NA	NA	NA	NA
1997	151.7	NA	NA	NA	NA	NA	NA
Nondefense R&D expenditures as a percentage of GDP							
1981	1.73	2.12	2.34	1.57	1.84	0.85	1.21
1982	1.79	2.21	2.44	1.66	NA	0.89	1.36
1983	1.80	2.34	2.43	1.74	1.69	0.93	1.33
1984	1.83	2.41	2.42	1.82	NA	0.97	1.36
1985	1.89	2.56	2.60	1.87	1.76	1.07	1.41
1986	1.86	2.53	2.61	1.84	1.82	1.08	1.44
1987	1.83	2.60	2.75	1.85	1.79	1.15	1.39
1988	1.84	2.63	2.74	1.85	1.80	1.15	1.34
1989	1.88	2.75	2.75	1.92	1.81	1.18	1.34
1990	1.97	2.83	2.62	1.95	1.84	1.26	1.43
1991	2.10	2.79	2.51	1.98	1.79	1.27	1.49
1992	2.07	2.73	2.39	2.04	1.83	1.27	NA
1993	1.98	2.65	2.35	2.10	1.85	1.21	1.59
1994	1.95	2.60	2.25	2.05	1.84	1.11	NA
1995	2.05	2.74	2.20	NA	1.78	1.11	1.58
1996	2.10	NA	NA	NA	NA	NA	NA
1997	2.15	NA	NA	NA	NA	NA	NA

NA = not available

[a] German data before 1991 are for West Germany only

[b] Conversions of foreign currencies to U.S. dollars are calculated with purchasing power parity exchange rates. Constant 1992 dollars are based on U.S. GDP implicit price deflators. (See appendix tables 4-1 and 4-2.)

SOURCES: National Science Foundation, Science Resources Studies Division, *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>; and Organisation for Economic Co-operation and Development, Main Science and Technology Indicators database (Paris: August 1997).

See figures 4-19 and 4-21.

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Appendix table 4-45.
International R&D expenditures, by performing sector and source of funds: Mid-1990s

R&D performer	Total	Source of R&D funds					Percent distribution, performers
		Industry	Government	Higher education	Private nonprofit	Abroad	
			Billions of yen				
Japan, 1995 total	13,358	9,644	2,741	874	83	14	100.0
Industry	9,396	9,223	149	–	10	13	70.3
Government	1,391	10	1,379	1	–	–	10.4
Higher education	1,932	45	1,012	872	3	–	14.5
Private nonprofit	640	366	201	1	70	1	4.8
Percent distribution, sources	100.0	72.2	20.5	6.5	0.6	0.1	
			Millions of deutsch marks				
Germany, 1996 total	79,860	48,800	29,430	0	260	1,370	100.0
Industry	53,100	47,250	4,750	–	100	1,000	66.5
Government	11,500	400	10,770	–	160	170	14.4
Higher education	15,260	1150	13,910	–	–	200	19.1
Private nonprofit	–	–	–	–	–	–	0.0
Percent distribution, sources	100.0	61.1	36.9	0.0	0.3	1.7	
			Millions of francs				
France, 1994 total	175,563	85,462	73,049	996	1,503	14,553	100.0
Industry	108,568	82,266	14,062	21	33	12,186	61.8
Government	36,217	1,916	32,675	56	27	1,543	20.6
Higher education	28,407	896	26,046	716	104	646	16.2
Private nonprofit	2,369	384	266	203	1,339	178	1.3
Percent distribution, sources	100.0	48.7	41.6	0.6	0.9	8.3	
			Millions of pounds				
United Kingdom, 1995 total	14,328	6,877	4,777	117	505	2,052	100.0
Industry	9,379	6,478	1,122	–	–	1,780	65.5
Government	2,076	228	1,752	3	34	59	14.5
Higher education	2,695	167	1,823	114	380	211	18.8
Private nonprofit	177	5	79	–	90	3	1.2
Percent distribution, sources	100.0	48.0	33.3	0.8	3.5	14.3	
			Billions of lire				
Italy, 1996 total	20,985	10,380	9,692	0	0	913	100.0
Industry	12,113	10,035	1,427	–	–	651	57.7
Government	4,174	85	3,946	–	–	142	19.9
Higher education	4,698	260	4,318	–	–	120	22.4
Private nonprofit	–	–	–	–	–	–	0.0
Percent distribution, sources	100.0	49.5	46.2	0.0	0.0	4.4	
			Millions of Canadian dollars				
Canada, 1996 total	12,939	6,029	4,538	296	343	1,357	100.0
Industry	8,143	5,670	777	–	–	1,321	62.9
Government	1,841	27	1,809	–	–	5	14.2
Higher education	2,775	296	1,901	296	263	18	21.4
Private nonprofit	180	36	51	–	80	13	1.4
Percent distribution, sources	100.0	46.6	35.1	2.3	2.7	10.5	

– = assumed negligible or no data available

SOURCE: Organisation for Economic Co-operation and Development, unpublished tabulations.

See figure 4-23.

Science & Engineering Indicators – 1998

Appendix table 4-46.

R&D expenditures in the United States, by performing sector and domestic and foreign source of funds: 1980, 1987, and 1995

(Millions of U.S. dollars)

R&D performer	Total	Source of R&D funds: Industry	Government	Higher education	Private nonprofit	Foreign	Percent distribution, performers
Total 1980 expenditures	63,076	29,409	29,857	1,382	911	1,517	100.0
Industry	44,505	28,959	14,029	–	–	1,517	70.6
Government	7,831	–	7,831	–	–	–	12.4
Higher education	8,565	250	6,522	1,382	411	–	13.6
Other nonprofit	2,175	200	1,475	–	500	–	3.4
Percent distribution, sources	100.0	46.6	47.3	2.2	1.4	2.4	
Total 1987 expenditures	125,840	58,173	58,253	3,259	1,658	4,497	100.0
Industry	92,155	56,906	30,752	–	–	4,497	73.2
Government	13,588	–	13,588	–	–	–	10.8
Higher education	16,768	811	11,843	3,259	855	–	13.3
Other nonprofit	3,329	456	2,070	–	803	–	2.6
Percent distribution, sources	100.0	46.2	46.3	2.6	1.3	3.6	
Total 1995 expenditures	183,013	96,026	63,147	5,739	3,129	14,972	100.0
Industry	132,103	93,680	23,451	–	–	14,972	72.2
Government	17,231	–	17,231	–	–	–	9.4
Higher education	27,708	1,516	18,839	5,739	1,613	–	15.1
Other nonprofit	5,971	830	3,626	–	1,516	–	3.3
Percent distribution, sources	100.0	52.5	34.5	3.1	1.7	8.2	

– = assumed negligible or no data available

NOTE: Foreign sources represent funding from companies in the United States with foreign ownership of 50 percent or more.

SOURCES: National Science Foundation, Science Resources Studies Division, *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>; and U.S. Bureau of Economic Analysis, unpublished tabulations.

See figure 4-23.

Science & Engineering Indicators – 1998

Appendix table 4-47.

Discrepancy between federal R&D support as reported by performers and by federal agencies: 1980-96

(Billions of dollars)

	All performers			Industrial performers		
	Performer-reported	Agency-reported	Difference	Performer-reported	Agency-reported	Difference
1980	29.9	29.8	0.0	12.8	13.0	-0.2
1981	33.7	33.1	0.6	15.0	14.9	0.1
1982	37.1	36.4	0.7	17.1	17.2	-0.1
1983	41.4	38.7	2.7	19.1	17.0	2.1
1984	46.3	42.2	4.1	21.7	18.6	3.0
1985	52.5	48.4	4.1	25.3	21.7	3.6
1986	54.5	51.4	3.1	26.0	24.2	1.8
1987	58.3	55.3	3.0	28.8	26.8	2.0
1988	59.9	56.8	3.2	28.2	26.7	1.5
1989	60.3	61.4	-1.1	26.4	28.5	-2.2
1990	61.5	63.6	-2.1	25.8	29.4	-3.6
1991	60.6	61.3	-0.7	24.1	26.4	-2.3
1992	60.7	65.6	-4.9	22.4	29.7	-7.4
1993	60.4	67.3	-7.0	20.8	30.2	-9.4
1994	60.7	67.3	-6.6	20.3	30.5	-10.2
1995	63.1	68.8	-5.6	21.2	30.5	-9.3
1996	62.8	69.1	-6.3	20.9	31.3	-10.3

NOTES: Performer-reported data are expenditures, and agency-reported data are obligations. Data for 1996 are preliminary. The differences in the two series are derived from unrounded data, not shown in the table.

SOURCES: National Science Foundation, Science Resources Studies Division (NSF/SRS), *National Patterns of R&D Resources: 1997 Data Update*, <<http://www.nsf.gov/sbe/srs/natpat97/start.htm>>; and NSF/SRS, *Federal Funds for Research and Development: Fiscal Years 1995, 1996, and 1997*, Detailed Statistical Tables, NSF 97-327 (Arlington, VA: 1997).

See figure 4-27.

Science & Engineering Indicators – 1998

Appendix table 4-48.

Distribution of strategic technology alliances between and within economic blocs, by technology: 1980-96

	Total[a]			Biotechnology			Information technologies			New materials		
	Total	Inter-region	Intra-region	Total	Inter-region	Intra-region	Total	Inter-region	Intra-region	Total	Inter-region	Intra-region
Number of international alliances												
1980	136	60	76	58	22	36	66	33	33	12	5	7
1981	156	66	90	46	13	33	95	46	49	15	7	8
1982	200	108	92	71	27	44	107	68	39	22	13	9
1983	210	106	104	45	20	25	133	69	64	32	17	15
1984	296	134	162	73	27	46	200	97	103	23	10	13
1985	386	160	226	132	54	78	201	84	117	53	22	31
1986	405	151	254	120	37	83	212	91	121	73	23	50
1987	404	164	240	126	56	70	212	83	129	66	25	41
1988	402	152	250	115	39	76	217	96	121	48	17	31
1989	355	148	207	78	37	41	233	92	141	44	19	25
1990	287	122	165	34	17	17	222	86	136	31	19	12
1991	264	119	145	34	17	17	212	95	117	18	7	11
1992	355	149	206	82	42	40	240	93	147	33	14	19
1993	399	165	234	117	50	67	226	92	134	56	23	33
1994	489	203	286	174	83	91	277	105	172	38	15	23
1995	587	244	343	199	98	101	340	122	218	48	24	24
1996	483	201	282	168	95	73	280	95	185	35	11	24
Percentage share, by interregional and intraregional distribution												
1980	100	44	56	100	38	62	100	50	50	100	42	58
1981	100	42	58	100	28	72	100	48	52	100	47	53
1982	100	54	46	100	38	62	100	64	36	100	59	41
1983	100	50	50	100	44	56	100	52	48	100	53	47
1984	100	45	55	100	37	63	100	49	52	100	43	57
1985	100	41	59	100	41	59	100	42	58	100	42	58
1986	100	37	63	100	31	69	100	43	57	100	32	68
1987	100	41	59	100	44	56	100	39	61	100	38	62
1988	100	38	62	100	34	66	100	44	56	100	35	65
1989	100	42	58	100	47	53	100	39	61	100	43	57
1990	100	43	57	100	50	50	100	39	61	100	61	39
1991	100	45	55	100	50	50	100	45	55	100	39	61
1992	100	42	58	100	51	49	100	39	61	100	42	58
1993	100	41	59	100	43	57	100	41	59	100	41	59
1994	100	42	58	100	48	52	100	38	62	100	39	61
1995	100	42	58	100	49	51	100	36	64	100	50	50
1996	100	42	58	100	57	43	100	34	66	100	31	69

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Appendix table 4-48.
Distribution of strategic technology alliances between and within economic blocs, by technology: 1980-96

	Total*			Biotechnology			Information technologies			New materials		
	Number of interregional alliances											
	Europe-Japan	Europe-U.S.	Japan-U.S.	Europe-Japan	Europe-U.S.	Japan-U.S.	Europe-Japan	Europe-U.S.	Japan-U.S.	Europe-Japan	Europe-U.S.	Japan-U.S.
1980	5	40	15	0	15	7	5	20	8	0	5	0
1981	10	30	26	1	4	8	7	23	16	2	3	2
1982	15	54	39	2	11	14	9	37	22	4	6	3
1983	18	37	51	2	12	6	12	19	38	4	6	7
1984	19	60	55	0	18	9	14	41	42	5	1	4
1985	26	82	52	7	30	17	13	44	27	6	8	8
1986	26	78	47	1	22	14	19	46	26	6	10	7
1987	16	95	53	5	37	14	6	48	29	5	10	10
1988	15	98	39	1	30	8	11	62	23	3	6	8
1989	18	86	44	7	21	9	8	56	28	3	9	7
1990	22	66	34	3	12	2	15	42	29	4	12	3
1991	15	53	51	1	14	2	12	37	46	2	2	3
1992	17	89	43	3	33	6	12	52	29	2	4	8
1993	16	104	45	2	38	10	10	48	34	4	18	1
1994	18	145	40	5	71	7	12	63	30	1	11	3
1995	23	167	54	7	84	7	12	69	41	4	14	6
1996	16	135	50	6	76	13	9	50	36	1	9	1
	Number of intraregional alliances											
	Europe	Japan	U.S.	Europe	Japan	U.S.	Europe	Japan	U.S.	Europe	Japan	U.S.
1980	29	5	42	10	1	25	13	4	16	6	0	1
1981	30	12	48	8	2	23	18	8	23	4	2	2
1982	27	8	57	6	2	36	17	4	18	4	2	3
1983	33	20	51	9	2	14	17	15	32	7	3	5
1984	59	15	88	14	4	28	40	7	56	5	4	4
1985	105	35	86	38	7	33	60	10	47	7	18	6
1986	78	58	118	15	16	52	52	15	54	11	27	12
1987	69	38	133	18	9	43	46	7	76	5	22	14
1988	86	23	141	31	5	40	48	7	66	7	11	13
1989	74	11	122	16	2	23	45	7	89	13	2	10
1990	34	10	121	5	0	12	25	9	102	4	1	7
1991	29	10	106	2	0	15	24	9	84	3	1	7
1992	41	10	155	10	1	29	25	9	113	6	0	13
1993	35	7	192	10	2	55	14	4	116	11	1	21
1994	39	12	235	25	1	65	9	9	154	5	2	16
1995	54	8	281	27	1	73	22	4	192	5	3	16
1996	43	11	228	20	0	53	18	8	159	5	3	16

*Includes all agreements reported for biotechnology, information technologies, and new materials.

SOURCE: J. Hagedoorn, Maastricht Economic Research Institute on Innovation and Technology, Cooperative Agreements and Technology Indicators database, unpublished tabulations.

See figures 4-31 and 4-32.

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Appendix table 4-49.

Proportion of industrial R&D expenditures financed from foreign sources, by selected country: 1980-96

(Percentages)

	Canada	France	Germany[a]	Italy	Japan	United Kingdom	United States
1980	NA	NA	NA	NA	NA	NA	3.4
1981	7.4	7.0	1.2	4.3	0.1	8.7	NA
1982	10.7	4.8	1.3	4.7	0.1	NA	NA
1983	16.6	4.6	1.4	4.3	0.1	6.8	NA
1984	17.1	6.5	1.5	6.2	0.1	NA	NA
1985	14.3	6.9	1.4	6.1	0.1	11.1	NA
1986	13.6	8.0	1.4	7.3	0.1	12.2	NA
1987	16.8	8.7	1.5	6.9	0.1	12.0	4.9
1988	18.0	9.2	2.1	6.6	0.1	12.0	5.7
1989	16.7	10.9	2.7	6.5	0.1	13.4	6.6
1990	17.4	11.1	2.7	7.3	0.1	15.5	7.8
1991	18.0	11.4	2.6	8.6	0.1	16.0	7.8
1992	NA	12.0	2.5	5.4	0.1	15.0	9.0
1993	17.2	11.3	1.9	5.9	0.1	15.4	9.6
1994	17.0	11.2	2.0	8.1	0.1	16.0	10.6
1995	NA	NA	1.9	5.4	0.1	19.0	11.3
1996	17.0	NA	1.9	5.4	NA	NA	NA

NA = not available

NOTE: There are no data on foreign sources of U.S. industrial R&D performance. The figures shown here to approximate such foreign involvement are the estimated percentages of U.S. industrial performance undertaken by majority-owned (that is, 50 percent or more) nonbank U.S. affiliates of foreign companies.

[a] German data before 1991 are for West Germany only.

SOURCES: U.S. Bureau of Economic Analysis, unpublished tabulations; and Organisation for Economic Co-operation and Development, Main Science and Technology Indicators database (Paris: August 1997).

See figure 4-24.

Appendix table 4-50.

Company-financed R&D performed abroad by U.S. companies and their foreign subsidiaries, by industry: 1985-95

Industry	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Millions of current U.S. dollars											
Total	3,650	4,624	5,226	6,208	6,706	7,952	9,147	10,063	9,565	9,395	13,052
Food, kindred, and tobacco products	75	69	37	27	42	41	66	88	112	117	142
Chemicals and allied products	843	1,071	1,243	1,548	1,532	2,007	2,401	2,676	2,833	2,456	4,194
Industrial and other chemicals	444	579	625	855	609	720	1,009	1,045	1,318	917	1,632
Drugs and medicines	399	492	618	693	923	1,287	1,392	1,631	1,561	1,539	2,562
Petroleum refining and extraction	47	40	47	59	47	76	107	119	104	111	76
Stone, clay, and glass products	D	D	D	D	D	59	38	41	38	27	31
Primary metals	D	D	18	23	24	26	20	18	12	15	26
Fabricated metal products	21	26	40	D	D	95	86	109	119	125	111
Machinery	689	951	1,233	1,326	1,432	1,451	1,476	1,439	340	308	501
Electrical equipment	591	D	432	591	573	770	651	568	525	495	872
Transportation equipment	1,025	D	D	1,750	1,916	2,055	2,402	D	D	D	D
Professional and scientific instruments	169	212	317	404	474	611	656	685	751	900	988
Nonmanufacturing industries	18	27	64	146	256	415	778	835	1,770	1,500	2,206
Millions of constant 1992 U.S. dollars[a]											
Total	4,646	5,738	6,292	7,210	7,474	8,492	9,399	10,063	9,321	8,951	12,134
Food, kindred, and tobacco products	95	86	45	31	47	44	68	88	109	111	132
Chemicals and allied products	1,073	1,329	1,496	1,798	1,707	2,143	2,467	2,676	2,761	2,340	3,899
Industrial and other chemicals	565	718	752	993	679	769	1,037	1,045	1,284	874	1,517
Drugs and medicines	508	610	744	805	1,029	1,374	1,430	1,631	1,521	1,466	2,382
Petroleum refining and extraction	60	50	57	69	52	81	110	119	101	106	71
Stone, clay, and glass products	D	D	D	D	D	63	39	41	37	26	29
Primary metals	D	D	22	27	27	28	21	18	12	14	24
Fabricated metal products	27	32	48	D	D	101	88	109	116	119	103
Machinery	877	1,180	1,484	1,540	1,596	1,550	1,517	1,439	331	293	466
Electrical equipment	752	D	520	686	639	822	669	568	512	472	811
Transportation equipment	1,305	D	D	2,032	2,135	2,195	2,468	D	D	D	D
Professional and scientific instruments	215	263	382	469	528	653	674	685	732	857	919
Nonmanufacturing industries	23	34	77	170	285	443	799	835	1,725	1,429	2,051

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Appendix table 4-50.

Company-financed R&D performed abroad by U.S. companies and their foreign subsidiaries, by industry: 1985-95

Industry	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
					Percentage of domestic funding						
Total	6.4	7.7	8.5	9.3	9.1	9.7	10.1	10.7	10.1	9.7	12.0
Food, kindred, and tobacco products	6.6	5.4	3.1	2.3	3.4	3.3	5.2	6.3	8.3	7.9	9.1
Chemicals and allied products	10.1	12.4	13.2	14.3	12.8	15.2	16.6	17.7	17.0	14.8	24.2
Industrial and other chemicals	9.2	11.6	11.7	14.4	9.5	9.9	13.5	14.6	17.5	13.2	22.9
Drugs and medicines	11.5	13.5	15.1	14.1	16.7	21.8	20.0	20.6	17.1	16.0	25.1
Petroleum refining and extraction	2.1	2.0	2.5	3.0	2.2	3.3	4.3	5.2	4.9	5.7	4.3
Stone, clay, and glass products	D	D	D	D	D	11.0	8.4	8.6	7.2	4.9	7.0
Primary metals	D	D	2.5	3.7	3.6	3.6	2.8	3.5	1.9	2.2	4.5
Fabricated metal products	2.7	3.3	6.3	D	D	12.9	11.5	15.1	12.7	14.4	11.8
Machinery	6.4	8.9	11.7	11.1	10.7	10.7	10.8	10.4	4.1	3.8	5.2
Electrical equipment	6.4	D	4.1	5.9	6.0	8.3	7.3	6.0	4.5	3.7	5.1
Transportation equipment	8.5	D	D	12.6	13.1	14.4	16.2	D	D	D	D
Professional and scientific instruments	3.7	4.5	6.4	7.6	8.3	9.7	9.6	9.4	10.0	11.2	11.6
Nonmanufacturing industries	0.4	0.6	1.2	2.0	2.5	2.5	3.4	3.6	7.2	6.3	8.0

D = withheld to avoid disclosing operations of individual companies

*See appendix table 4-1 for GDP implicit price deflators used to convert current dollars to constant 1992 dollars.

SOURCE: National Science Foundation, Science Resources Studies Division, *Research and Development in Industry: 1995* (Arlington, VA: 1998, forthcoming).

See figure 4-35.

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Appendix table 4-51.

Expenditures for R&D performance for majority-owned foreign affiliates of U.S. parent companies, by region/country: 1982 and 1989-94

(Millions of U.S. dollars)

Region/country	1982	1989	1990	1991	1992	1993	1994
Total	3,647	7,048	10,187	9,396	11,084	10,951	11,482
Canada	545	914	1,159	1,039	1,006	1,025	852
Europe	2,591	5,178	7,952	7,143	8,024	7,533	8,255
Belgium	181	317	388	383	458	455	523
France	263	545	882	907	1,021	941	1,249
Germany	893	1,496	2,561	2,504	2,726	2,567	3,216
Ireland	31	134	539	573	664	664	464
Italy	136	294	476	327	326	304	389
Netherlands	101	360	459	478	482	393	260
Spain	36	115	103	100	323	320	D
Sweden	29	33	130	83	84	48	67
Switzerland	51	67	76	91	101	109	145
United Kingdom	805	1,673	2,221	1,606	1,737	1,634	1,706
Other European countries	65	144	117	91	102	98	D
Asia and Pacific	294	760	846	916	1,719	1,964	1,817
Japan	104	488	512	596	664	881	1,088
Australia	120	181	197	144	173	175	225
Singapore	D	25	54	87	360	312	243
Other Asian and Pacific countries	D	66	83	89	522	596	261
Latin America and other Western Hemisphere	179	153	201	253	291	383	502
Brazil	96	90	113	149	172	220	253
Mexico	38	37	53	64	76	D	189
Other Latin America	45	26	35	40	43	D	60
Middle East	11	32	16	30	25	28	38
Africa	26	11	13	15	19	18	19
South Africa	23	9	10	12	16	14	14
Other African countries	3	2	3	3	3	4	5

D = withheld to avoid disclosing operations of individual companies

NOTES: The data include foreign direct investments of nonbank U.S. affiliates conducted by and for the foreign affiliates. The data exclude expenditures for R&D conducted for others under a contract. Benchmark survey statistics are reported for 1982, 1989, and 1994. Data are preliminary for 1994. Expenditures reported here differ from the data in appendix table 4-50.

SOURCE: U.S. Bureau of Economic Analysis, *U.S. Direct Investment Abroad: Operations of U.S. Parent Companies and Their Foreign Affiliates* (Washington, DC: U.S. Government Printing Office, annual series).

See figures 4-33, 4-34, and 4-36.

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Appendix table 4-52.

Foreign R&D expenditures in the United States, by industry and region/country: 1980-95

(Millions of current U.S. dollars)

Industry and region/country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Total	1,946	3,110	3,744	4,164	4,738	5,240	5,804	6,521	7,834	9,465	11,522	11,872	13,864	14,199	15,566	17,666
Expenditures by industry																
Petroleum	D	253	255	310	366	388	380	311	364	387	520	438	586	428	407	387
Manufacturing	D	2,645	3,133	3,553	4,058	4,478	5,011	5,573	6,903	8,398	9,868	10,177	11,383	11,842	12,970	14,743
Food and kindred products	19	32	39	44	43	51	54	58	106	187	192	195	245	266	294	301
Chemicals and allied products	834	1,580	1,870	2,037	2,349	2,627	2,782	3,220	3,719	4,371	5,243	5,755	D	6,580	7,003	8,326
Industrial chemicals	454	1,085	1,329	1,397	1,620	1,836	1,657	1,899	2,126	2,284	2,498	2,391	D	1,906	1,993	2,540
Other chemicals	146	179	170	181	200	228	167	230	276	252	372	427	490	442	504	531
Drugs and medicines	234	316	371	459	529	563	958	1,091	1,318	1,835	2,373	2,937	3,211	4,232	4,506	5,255
Primary metal industries	24	71	79	59	66	102	97	91	102	155	166	189	173	201	170	172
Fabricated metal products	21	20	28	82	54	64	76	67	106	209	152	145	D	172	178	176
Machinery, except electrical	189	284	297	350	355	342	286	476	692	1,070	1,190	1,094	1,098	1,019	954	1,089
Office and computing machines	NA	NA	NA	NA	NA	NA	NA	370	497	622	794	788	774	624	479	552
Other	NA	NA	NA	NA	NA	NA	NA	106	195	448	396	306	324	395	475	537
Electrical equipment	318	385	505	613	799	977	1,366	1,105	1,389	1,371	1,817	1,647	1,953	2,168	2,613	2,770
Transportation equipment	101	136	150	92	95	83	124	76	225	265	193	207	D	266	375	478
Professional and scientific instruments	32	52	47	42	42	58	112	279	242	366	420	472	D	581	671	682
Nonmanufacturing industries	D	212	356	301	314	374	413	637	567	680	1,134	1,257	1,895	1,929	2,189	2,536
Services	37	43	41	51	60	54	77	243	69	108	384	358	744	932	996	922
Other	D	169	315	250	254	320	336	394	498	572	750	899	1,151	997	1,193	1,614
Expenditures by region/country																
Canada	135	777	1,032	1,212	1,405	1,550	1,542	1,666	1,804	1,758	1,944	2,060	2,113	2,159	2,332	1,396
Europe	1,544	1,936	2,229	2,324	2,632	2,918	3,450	3,881	4,754	6,022	7,520	7,785	8,993	9,362	10,313	13,370
United Kingdom	312	405	520	559	664	748	764	833	1,171	1,645	1,889	2,046	2,177	2,211	2,499	2,419
Germany	380	436	529	591	602	671	851	1,139	1,242	1,503	1,764	1,720	2,100	2,209	2,425	3,976
France	146	204	232	215	261	166	352	366	435	572	812	953	1,204	1,235	1,449	1,644
Netherlands	299	373	397	387	432	514	517	542	618	703	784	663	696	697	736	838
Switzerland	338	416	447	463	546	625	744	765	962	1,195	1,669	1,849	2,064	2,423	2,444	3,088
Sweden	36	53	54	62	63	116	141	128	166	214	281	237	308	200	289	807
Other European countries	33	49	50	47	64	78	81	108	160	190	321	317	444	387	471	598
Japan	88	142	141	171	210	267	292	307	571	822	1,307	1,353	1,709	1,801	1,790	1,867
Latin America	D	D	D	401	423	427	427	391	352	400	386	397	580	539	637	280
All other countries	D	D	D	56	68	78	93	276	353	463	365	277	469	338	494	753

D = withheld to avoid disclosing operations of individual companies; NA = not available

NOTES: The data include foreign direct investments of nonbank U.S. affiliates with 10 percent or more foreign ownership and exclude expenditures for R&D conducted for others under a contract.

SOURCE: U.S. Bureau of Economic Analysis, *Foreign Direct Investment in the United States: Operations of U.S. Affiliates of Foreign Companies* (Washington, DC: U.S. Government Printing Office, annual series).

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Appendix table 4-53.

R&D expenditures in the United States by majority-owned nonbank U.S. affiliates of foreign companies, by industry of affiliate and country of ultimate beneficial owner: 1980 and 1987-95

(Millions of current U.S. dollars)

Industry and region/country	1980	1987	1988	1989	1990	1991	1992	1993	1994	1995
Total	1,517	4,497	5,485	6,720	8,511	9,127	10,745	11,262	12,671	14,972
Expenditures by industry										
Petroleum	175	283	339	378	D	D	551	420	400	382
Manufacturing	1,245	3,809	4,773	5,915	7,282	7,839	9,056	9,560	10,855	12,913
Food and kindred products	19	58	105	185	189	190	240	260	283	294
Chemicals and allied products	733	D	D	D	3,832	4,266	4,692	5,167	5,654	7,298
Industrial and other chemicals	501	D	D	D	1,465	D	D	D	1,429	2,919
Drugs and medicines	232	1,075	1,293	1,806	2,367	D	D	D	4,225	4,379
Rubber products	8	50	98	117	155	150	305	216	210	211
Stone, clay, and glass products	10	32	61	62	114	102	113	106	151	157
Primary metal industries	D	38	37	75	69	82	79	83	77	71
Fabricated metal products	D	62	100	201	138	132	136	155	165	162
Machinery, except electrical	92	D	446	556	645	602	609	529	551	636
Computer and office equipment	28	D	285	295	380	341	328	247	203	248
Other	65	79	161	260	264	261	281	282	348	388
Electrical and electronic equipment	285	D	1,114	1,078	1,533	1,562	1,880	2,061	2,549	2,704
Household audio & video, and comm. equip.	66	555	777	721	971	959	1,129	1,133	1,345	1,515
Electronic components and other	219	D	337	357	562	603	752	928	1,204	1,189
Transportation equipment	10	D	D	D	106	159	203	231	331	434
Professional and scientific instruments	28	254	210	295	333	411	556	524	578	593
Nonmanufacturing industries	97	405	373	427	D	D	1,138	1,282	1,416	1,677
Services	5	59	42	77	D	D	211	420	455	430
Wholesale trade	69	312	300	297	571	682	803	745	839	1,113
Motor vehicles and equipment	D	86	67	71	283	277	252	220	182	179
Electrical goods	5	71	107	D	145	224	220	157	236	336
Other	23	34	31	53	D	D	124	117	122	134

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Appendix table 4-53.
R&D expenditures in the United States by majority-owned nonbank U.S. affiliates of foreign companies, by industry of affiliate and country of ultimate beneficial owner: 1980 and 1987-95
(Millions of current U.S. dollars)

Industry and region/country	1980	1987	1988	1989	1990	1991	1992	1993	1994	1995
	Expenditures by region/country									
Canada	113	D	D	D	D	D	D	D	D	1,350
Europe	1,217	3,458	4,241	5,414	6,762	7,275	8,325	8,628	9,487	11,609
France	39	332	402	510	766	913	1,230	1,190	1,383	1,572
Germany	281	824	963	1,216	1,435	1,596	1,855	2,003	2,147	3,663
Italy	D	D	73	93	151	143	91	132	157	180
Netherlands	D	540	615	690	757	642	685	674	719	816
Sweden	D	124	160	205	271	225	322	180	263	D
Switzerland	329	D	D	1,060	1,455	1,637	1,873	2,117	2,127	2,471
United Kingdom	247	790	1,085	1,568	1,809	1,987	2,090	2,139	2,428	2,315
Other European countries	16	47	D	72	118	132	179	193	263	D
Asia and Pacific	D	179	345	412	796	834	1,080	1,232	1,397	1,646
Japan	D	133	282	369	709	741	938	1,112	1,200	1,281
Other	D	46	63	43	87	93	142	120	197	365
Latin America & other Western Hemisphere	155	329	302	352	314	330	534	D	610	274
Middle East	2	14	9	10	9	9	20	38	62	71
Africa	D	D	D	D	D	D	4	5	2	D

D = withheld to avoid disclosing operations of individual companies

NOTES: The data include foreign direct investments of nonbank U.S. affiliates with 50 percent or more foreign ownership. These R&D expenditures are a subset of total foreign R&D expenditures reported in appendix table 4-52. The data exclude expenditures for R&D conducted for others under a contract.

SOURCE: U.S. Bureau of Economic Analysis, unpublished tabulations.

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See figures 4-33, 4-34, and 4-37.

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Appendix table 4-54.
Support for R&D and R&D plant from state government sources: 1995

	Support for R&D and R&D plant (thousand $)	Ranking	Dollars per capita	Ranking	Share state spending (percent)	Ranking
Total states	2,514,169		9.59		0.35	
Alabama	230	50	0.05	50	0.00	50
Alaska	5,167	42	8.56	27	0.11	39
Arizona	68,627	12	16.27	10	0.68	6
Arkansas	2,142	43	0.86	44	0.03	44
California	248,756	1	7.87	29	0.29	27
Colorado	24,135	24	6.44	33	0.30	24
Connecticut	6,986	40	2.13	41	0.06	41
Delaware	7,240	39	10.10	18	0.22	32
Florida	245,154	2	17.31	7	0.63	8
Georgia	183,526	4	25.49	4	1.02	3
Hawaii	35,406	23	29.83	2	0.57	9
Idaho	14,304	29	12.30	12	0.52	12
Illinois	105,513	7	8.92	24	0.40	17
Indiana	23,838	25	4.11	37	0.20	34
Iowa	49,240	17	17.33	6	0.54	10
Kansas	80,907	10	31.54	1	1.09	2
Kentucky	5,462	41	1.42	42	0.05	42
Louisiana	12,338	32	2.84	40	0.08	40
Maine	12,140	34	9.78	19	0.32	23
Maryland	48,983	18	9.72	21	0.34	21
Massachusetts	21,803	27	3.59	38	0.12	38
Michigan	58,959	15	6.17	34	0.22	31
Minnesota	23,671	26	5.13	36	0.17	35
Mississippi	1,743	44	0.65	47	0.03	47
Missouri	55,448	16	10.41	17	0.48	13
Montana	10,456	37	12.02	13	0.45	15
Nebraska	45,816	19	27.99	3	1.12	1
Nevada	984	45	0.64	48	0.03	46
New Hampshire	10,584	36	9.22	22	0.46	14
New Jersey	69,009	11	8.69	26	0.30	25
New Mexico	12,846.69	31	7.62	30	0.21	33
New York	149,597	6	8.25	28	0.24	30
North Carolina	100,161	8	13.92	11	0.54	11
North Dakota	15,676	28	24.46	5	0.89	4
Ohio	82,989	9	7.44	31	0.28	28
Oklahoma	9,977	38	3.04	39	0.13	37
Oregon	35,677	22	11.36	15	0.33	22
Pennsylvania	204,850	3	16.97	8	0.65	7
Rhode Island	746	47	0.75	46	0.02	48
South Carolina	40,529	21	11.03	16	0.38	20
South Dakota	12,324	33	16.91	9	0.74	5
Tennessee	755	46	0.14	49	0.01	49
Texas	169,570	5	9.06	23	0.43	16
Utah	13,936	30	7.14	32	0.29	26
Vermont	490	49	0.84	45	0.03	45
Virginia	64,707	13	9.78	20	0.38	19
Washington	64,021	14	11.79	14	0.39	18
West Virginia	11,138	35	6.09	35	0.13	36
Wisconsin	45,033	20	8.79	25	0.28	29
Wyoming	557	48	1.16	43	0.03	43

NOTE: These are preliminary tabulations subject to revision and refinement.

SOURCE: Battelle Memorial Institute and the State Science and Technology Institute, *Survey of State Research and Development Expenditures: FY 1995* (Columbus, OH: forthcoming).

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Appendix table 4-55.
State R&D expenditures, by performing sector and source of funds: 1995
(Millions of current dollars)

Performing sector:		Total R&D	Federal Govt.	Industry			Universities & colleges						U&C FFRDCs	Other nonprofit institutions[a]	Nonprofit FFRDCs
Funding sector:		Total R&D	Federal Govt.	Total	Federal Govt.[b]	Industry[b]	Total	Federal Govt.	Nonfederal govt.	Industry	U&C	Nonprofits	Federal Govt.[c]	Federal Govt.	Federal Govt.
State	Rank														
United States, total		183,013	17,343	132,103	23,451	108,652	22,101	13,331	1,655	1,492	4,024	1,599	5,405	2,806	831
Alabama	25	1,681	642	686	273	413	335	190	7	29	87	22	0	18	0
Alaska	47	163	61	30	D	D	72	37	6	5	24	0	0	1	0
Arizona	24	1,995	178	1,356	620	736	380	210	8	23	126	12	75	6	0
Arkansas	44	330	58	181	D	D	88	33	24	8	20	3	0	3	0
California	1	36,133	1,844	28,710	6,925	21,785	2,594	1,797	107	120	373	198	2,378	362	245
Colorado	20	2,603	168	1,865	274	1,591	394	260	22	24	52	35	125	46	5
Connecticut	13	4,311	18	3,906	389	3,517	377	228	19	20	78	32	0	10	0
Delaware	28	1,149	15	1,077	12	1,065	53	27	2	4	15	5	0	3	0
District of Columbia	18	3,128	2,106	672	17	656	181	133	1	13	20	15	0	169	0
Florida	12	5,223	554	4,101	1,634	2,467	559	317	41	36	135	29	0	8	0
Georgia	23	2,113	272	1,175	142	1,031	658	302	54	55	222	25	0	8	0
Hawaii	38	509	402	14	D	D	78	44	27	0	4	3	0	15	0
Idaho	32	914	28	827	D	D	59	20	14	7	16	2	0	1	0
Illinois	7	7,487	81	5,776	146	5,630	818	468	47	43	195	65	771	41	0
Indiana	17	3,163	62	2,721	382	2,339	376	197	22	35	101	20	0	4	0
Iowa	27	1,391	37	998	D	D	323	164	47	19	78	15	32	1	0
Kansas	34	764	12	569	D	D	181	70	39	11	53	8	0	1	0
Kentucky	36	594	6	452	4	448	135	60	10	17	44	5	0	1	0
Louisiana	41	423	45	61	D	D	315	136	72	21	66	19	0	2	0
Maine	42	345	4	286	D	D	32	16	2	4	9	1	0	23	0
Maryland	9	6,519	4,159	1,075	287	788	1,160	895	76	55	85	50	0	123	2
Massachusetts	4	9,969	316	7,416	1,458	5,958	1,147	825	13	89	92	128	345	587	159
Michigan	2	13,275	82	12,388	148	12,240	755	418	49	51	181	57	0	50	0
Minnesota	19	3,087	30	2,636	315	2,321	337	195	50	23	46	23	0	85	0
Mississippi	45	315	133	66	D	D	113	63	24	9	11	6	0	3	0
Missouri	21	2,499	55	2,028	584	1,443	397	213	21	37	93	33	0	18	0
Montana	48	119	34	17	D	D	67	27	13	6	20	1	0	2	0
Nebraska	43	336	23	150	D	D	157	55	42	11	46	3	0	6	0
Nevada	40	445	35	322	D	D	87	48	6	7	25	1	0	1	0
New Hampshire	35	598	31	472	36	436	93	60	4	4	13	12	0	2	0
New Jersey	5	9,128	344	8,200	197	8,002	443	209	40	26	136	33	126	11	4
New Mexico	15	3,295	481	1,461	1,380	81	230	157	17	11	39	7	1,109	6	7
New York	3	10,954	117	8,651	1,821	6,831	1,702	1,107	96	98	206	195	281	203	0
North Carolina	16	3,191	220	2,226	15	2,212	687	432	98	74	62	21	0	59	0
North Dakota	49	98	25	12	D	D	60	28	2	3	25	2	0	1	0
Ohio	10	5,314	599	4,001	574	3,428	643	375	48	54	107	59	0	72	0
Oklahoma	37	529	45	288	38	249	186	60	20	11	79	17	0	9	0
Oregon	30	1,069	56	741	35	706	259	158	30	12	37	21	0	33	0
Pennsylvania	8	6,919	228	5,331	376	4,955	1,140	754	35	120	164	66	32	189	0
Rhode Island	33	896	254	520	D	D	106	72	3	2	26	2	0	17	0

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Appendix table 4-55.
State R&D expenditures, by performing sector and source of funds: 1995
(Millions of current dollars)

Performing sector		Total R&D	Federal Govt	Industry			Universities & colleges						U&C FFRDCs	Other nonprofit institutions[a]	Nonprofit FFRDCs
Funding sector		Total R&D	Federal Govt	Total	Federal Govt.[b]	Industry[b]	Total	Federal Govt.	Nonfederal govt.	Industry	U&C	Nonprofits	Federal Govt.[c]	Federal Govt.	Federal Govt.
State	Rank														
South Carolina	31	996	34	739	D	D	220	109	18	19	54	19	0	3	0
South Dakota	51	55	13	19	0	19	21	11	7	0	2	1	0	1	0
Tennessee	26	1,402	62	1,003	D	D	308	192	35	16	45	20	10	20	0
Texas	6	8,385	538	6,211	912	5,298	1,472	748	159	102	297	167	0	163	1
Utah	29	1,144	131	803	178	625	202	141	15	9	28	9	0	8	0
Vermont	46	308	5	248	D	D	54	33	2	5	10	4	0	1	0
Virginia	14	3,897	1,581	1,577	743	834	447	262	47	46	64	28	74	42	177
Washington	11	5,241	160	4,294	D	D	486	340	14	39	77	15	0	96	205
West Virginia	39	475	140	243	D	D	53	30	2	3	13	4	33	6	0
Wisconsin	22	2,226	40	1,706	33	1,673	473	271	43	17	92	51	0	7	0
Wyoming	50	87	9	25	D	D	40	15	3	2	17	3	0	13	0
Other/unknown		5,805	771	1,772	3,502	8,875	548	320	53	30	114	30	16	248	26

FFRDCs = federally funded research and development centers; U&C = universities and colleges; D = data have been withheld to avoid disclosing information about individual companies

NOTES: Data are based on annual reports by performers, except for the nonprofit sector. Details may not sum to totals because of rounding.

[a] State data for nonprofit performance using nonfederal funds are not available. For 1995, total nonprofit performance is estimated at $5,152 million. Industry provided an estimated $830 million to the nonprofit sector, and nonprofit institutions provided an estimated $1,516 million. These amounts are included in the total R&D "other/unknown" category.

[b] Federal support for industry R&D includes performance at industry FFRDCs; industry support of industry R&D includes all nonfederal sources.

[c] Includes total R&D expenditures of FFRDCs administered by academic institutions.

SOURCES: National Science Foundation, Science Resources Studies Division (NSF/SRS), *Research and Development in Industry: 1995* (Arlington, VA: 1998, forthcoming); NSF/SRS, *Academic Science and Engineering R&D Expenditures: Fiscal Year 1995, Detailed Statistical Tables* (Arlington, VA: 1998, forthcoming); and NSF/SRS, *Federal Funds for Research and Development: Fiscal Years 1995, 1996, and 1997*, Detailed Statistical Tables, NSF 97-327 (Arlington, VA: 1997).

Appendix table 4-56.
Annual aggregate data on independent research and development: FYs 1963-96
(Millions of current dollars)

		Accepted by government IR&D program						R&D obligations[a]		Percent of R&D performed by industry with funding from:[b]	
	Incurred by industry	Total accepted	DOD share	NASA share	Not reimbursed	Not accepted under IR&D program	DOD and NASA IR&D reimbursement	DOD to industry	NASA to industry	DOD & NASA (1)	DOD (2)
1963	439	255	197	24	34	184	221	5,173	2,307	3.0	3.8
1964	419	272	199	50	23	147	249	4,880	3,369	3.0	4.1
1965	439	300	198	60	42	139	258	4,362	3,853	3.1	4.5
1966	502	357	224	69	64	145	293	4,557	3,928	3.5	4.9
1967	591	439	277	58	104	152	335	5,428	3,798	3.6	5.1
1968	776	579	338	61	180	197	399	5,090	3,382	4.7	6.6
1969	808	653	410	43	200	155	453	5,157	2,899	5.6	8.0
1970	753	597	376	44	177	156	420	4,524	2,521	6.0	8.3
1971	703	567	354	41	172	136	395	4,629	2,077	5.9	7.6
1972	936	725	392	40	293	211	432	5,108	1,960	6.1	7.7
1973	1,164	876	441	40	395	288	481	5,138	1,961	6.8	8.6
1974	1,175	921	467	39	415	254	506	5,173	1,785	7.3	9.0
1975	1,224	1,010	493	40	477	214	533	5,640	1,792	7.2	8.7
1976	1,388	1,061	544	41	476	327	585	6,019	2,042	7.3	9.0
1977	1,560	1,199	598	46	555	361	644	6,997	2,002	7.2	8.5
1978	1,788	1,365	643	49	673	423	692	7,317	2,043	7.4	8.8
1979	2,104	1,517	708	54	755	587	762	7,695	2,270	7.6	9.2
1980	2,373	1,728	812	57	859	645	869	9,022	1,924	7.9	9.0
1981	[illegible]	2,039	1,056	66	917	757	1,122	10,826	2,096	8.7	9.8
1982	[illegible]	2,821	1,338	67	1,416	833	1,405	13,795	1,433	9.2	9.7
1983	4,0[illegible]	2,961	1,601	78	1,282	1,056	1,679	14,541	1,030	10.8	11.0
1984	5,17[illegible]	3,897	1,884	86	1,927	1,276	1,970	15,967	1,263	11.4	11.8
1985	5,036	3,500	2,099	88	1,313	1,536	2,187	18,944	1,576	10.7	11.1
1986	5,042	3,537	2,198	77	1,262	1,505	2,275	21,502	1,584	9.9	10.2
1987	4,885	3,544	2,186	67	1,291	1,341	2,253	23,934	1,463	8.9	9.1
1988	4,825	3,694	2,181	89	1,424	1,131	2,270	23,295	1,962	9.0	9.4
1989	4,866	3,798	2,233	110	1,455	1,068	2,343	24,734	2,426	8.6	9.0
1990	4,910	3,766	2,158	131	1,477	1,144	2,289	24,443	3,285	8.3	8.8
1991	5,099	4,327	2,203	133	1,991	772	2,336	21,034	3,667	9.5	10.5
1992	4,903	4,320	2,117	84	2,119	583	2,201	24,107	3,765	7.9	8.8
1993	3,337	3,085	1,904	151	1,030	252	2,055	23,654	4,112	7.4	8.0
1994	3,068	2,842	1,746	167	929	226	1,913	23,408	4,305	6.9	7.5
1995	2,848	2,720	1,619	167	934	128	1,786	22,553	4,687	6.6	7.2
1996	3,031	2,863	1,768	172	923	168	1,940	24,395	5,258	6.5	7.2

DOD = Department of Defense; IR&D = independent research and development; NASA = National Aeronautics and Space Administration

NOTES: The significant decrease in reported statistics between FYs 1992 and 1993 is primarily due to (1) change in the Federal Acquisition Regulations definition of "major contractor" and (2) change in the Defense Contract Audit Agency criteria used in determining contractors to be reported. Previously, these criteria included contractors with auditable costs of $40 million or more; the current threshold is $70 million or more. The increase in the percentage of IR&D costs accepted is due to an expansion of the activities eligible for reimbursement.

[a] Includes R&D performed by federally funded research and development centers administered by the industrial sector.

[b] Percentages were calculated as follows: numerator in (1) is total DOD and NASA IR&D reimbursements, and denominator is total DOD and NASA R&D performed by industry, excluding IR&D; numerator in (2) is total DOD IR&D reimbursements, and denominator is DOD R&D performed by industry, excluding IR&D.

SOURCES: Defense Contract Audit Agency, *Independent Research and Development and Bid and Proposal Costs Incurred by Major Defense Contractors 1976-96* (Washington, DC: annual series); NASA, unpublished tabulations; J. Reppy, "Defense Department Payments for 'Company-Financed' R&D," Research Policy Vol. 6, No. 4 (October 1977): p. 403; National Science Foundation, Science Resources Studies Division (NSF/SRS), *Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1956-1996*, NSF 96-320 (Arlington, VA: 1996); and NSF/SRS, *Federal Funds for Research and Development: Fiscal Years 1995, 1996, and 1997*, Detailed Statistical Tables, NSF 97-327 (Arlington, VA: 1997).

Appendix table 5-1.

Total, federally funded, and nonfederally funded academic R&D, by basic research, applied research, and development: 1960-97

(Percentages)

	Total academic R&D				Federally supported academic R&D				Nonfederally supported academic R&D			
	Total academic	Basic research	Applied research	Development	Total academic	Basic research	Applied research	Development	Total academic	Basic research	Applied research	Development
1960	100.0	68.8	26.3	4.9	64.2	75.2	20.6	4.2	35.8	57.1	36.7	6.2
1961	100.0	71.7	23.8	4.5	66.8	77.5	18.6	3.9	33.2	59.9	34.3	5.8
1962	100.0	74.2	21.8	4.0	69.2	79.5	17.3	3.3	30.8	62.4	31.9	5.7
1963	100.0	77.1	19.5	3.4	71.2	82.2	15.2	2.6	28.8	64.7	30.0	5.3
1964	100.0	77.9	18.6	3.5	72.4	82.8	14.3	3.0	27.6	65.1	29.9	5.0
1965	100.0	76.5	19.0	4.4	73.2	80.8	15.0	4.1	26.8	64.8	29.9	5.3
1966	100.0	75.9	19.3	4.8	73.4	79.9	15.6	4.6	26.6	65.0	29.6	5.4
1967	100.0	76.3	19.1	4.6	73.2	79.7	15.9	4.4	26.8	67.2	27.7	5.1
1968	100.0	76.8	18.5	4.6	72.5	79.8	15.7	4.5	27.5	69.1	25.9	5.0
1969	100.0	76.9	18.3	4.8	71.2	79.3	15.8	4.9	28.8	71.0	24.4	4.6
1970	100.0	76.7	18.6	4.6	69.7	78.5	16.6	5.0	30.3	72.7	23.4	3.9
1971	100.0	76.7	19.5	3.8	68.6	78.7	17.4	3.9	31.4	72.4	24.0	3.6
1972	100.0	73.9	22.4	3.7	68.6	76.0	20.7	3.3	31.4	69.3	26.3	4.4
1973	100.0	71.2	24.5	4.2	68.0	74.1	22.4	3.5	32.0	65.1	29.1	5.8
1974	100.0	71.0	24.7	4.4	67.2	74.5	22.1	3.4	32.8	63.7	30.0	6.3
1975	100.0	69.5	26.2	4.4	67.2	73.7	22.9	3.4	32.8	60.9	32.9	6.3
1976	100.0	68.6	26.7	4.7	67.2	73.5	22.7	3.8	32.8	58.7	34.9	6.5
1977	100.0	68.5	26.1	5.4	66.8	73.3	21.9	4.7	33.2	58.9	34.4	6.8
1978	100.0	67.7	25.3	7.1	66.4	72.3	20.7	7.0	33.6	58.4	34.4	7.2
1979	100.0	67.2	24.6	8.2	67.2	71.1	20.1	8.7	32.8	59.2	33.8	7.1
1980	100.0	66.7	25.1	8.1	67.4	70.2	21.2	8.6	32.6	59.5	33.2	7.3
1981	100.0	67.0	25.1	7.9	66.3	71.3	20.6	8.1	33.7	58.4	34.1	7.5
1982	100.0	66.8	25.2	8.0	64.6	71.3	20.4	8.3	35.4	58.6	34.0	7.5
1983	100.0	67.1	25.4	7.5	63.2	70.9	21.3	7.7	36.8	60.4	32.5	7.1
1984	100.0	66.8	25.7	7.4	62.9	70.8	21.6	7.6	37.1	60.1	32.8	7.2
1985	100.0	67.9	24.7	7.3	62.3	71.9	20.6	7.6	37.7	61.4	31.6	6.9
1986	100.0	68.7	24.1	7.2	61.2	72.7	19.8	7.5	38.8	62.4	30.8	6.8
1987	100.0	68.3	24.6	7.1	60.5	72.1	20.5	7.4	39.5	62.3	30.9	6.8
1988	100.0	65.9	26.4	7.8	60.6	69.2	22.6	8.2	39.4	60.8	32.2	7.1
1989	100.0	65.4	26.9	7.7	59.8	68.9	23.0	8.1	40.2	60.1	32.7	7.2
1990	100.0	65.5	26.3	8.2	58.9	69.2	21.9	8.9	41.1	60.3	32.6	7.1
1991	100.0	66.1	25.4	8.5	58.4	69.6	20.8	9.6	41.6	61.2	31.8	7.0
1992	100.0	66.5	25.2	8.3	59.2	69.7	21.0	9.2	40.8	61.9	31.2	6.9
1993	100.0	66.7	25.1	8.2	60.0	70.4	20.6	9.0	40.0	61.3	31.7	7.0
1994	100.0	67.0	24.7	8.3	60.2	70.9	20.0	9.1	39.8	61.1	31.9	7.0
1995	100.0	67.0	24.8	8.2	60.2	71.1	20.0	8.9	39.8	60.9	32.1	7.0
1996 (est.)	100.0	67.0	25.0	8.0	59.9	71.0	20.3	8.7	40.1	61.0	32.0	7.0
1997 (est.)	100.0	67.0	24.9	8.1	59.4	71.0	20.1	8.9	40.6	61.1	31.9	7.0

NOTE: See appendix tables 4-4, 4-5, 4-6, and 4-7 for the data underlying these percentages.

SOURCES: National Science Foundation (NSF), Science Resources Studies Division, *National Patterns of R&D Resources: 1996*, NSF 96-333 (Arlington, VA: 1996); and NSF, unpublished tabulations.

See figure 5-2.

Appendix table 5-2.
Support for academic R&D, by sector: FYs 1960-97

		Source of support				
	Total	Federal Government	State/local government	Industry	Academic institutions	All other sources
		Millions of current dollars				
1960	646	405	85	40	64	52
1961	763	500	95	40	70	58
1962	904	613	106	40	79	66
1963	1,081	760	118	41	89	73
1964	1,275	917	132	40	103	83
1965	1,474	1,073	143	41	124	93
1966	1,715	1,261	156	42	148	108
1967	1,921	1,409	164	48	181	119
1968	2,149	1,572	172	55	218	132
1969	2,225	1,600	197	60	223	145
1970	2,335	1,647	219	61	243	165
1971	2,500	1,724	255	70	274	177
1972	2,630	1,795	270	74	305	187
1973	2,884	1,985	295	84	318	202
1974	3,023	2,032	307	96	370	218
1975	3,409	2,288	332	113	417	259
1976	3,729	2,512	364	123	446	285
1977	4,067	2,726	374	139	514	314
1978	4,625	3,059	414	170	623	359
1979	5,366	3,598	472	193	735	368
1980	6,063	4,098	491	236	835	403
1981	6,847	4,571	546	291	1,004	435
1982	7,324	4,768	616	337	1,111	491
1983	7,882	4,989	626	389	1,302	576
1984	8,620	5,431	690	475	1,411	613
1985	9,687	6,064	752	560	1,617	694
1986	10,928	6,712	915	700	1,869	732
1987	12,153	7,343	1,023	790	2,168	828
1988	13,463	8,193	1,106	872	2,356	935
1989	14,976	8,990	1,223	995	2,697	1,071
1990	16,285	9,636	1,324	1,128	3,006	1,191
1991	17,584	10,232	1,473	1,205	3,367	1,307
1992	18,816	11,090	1,491	1,280	3,547	1,409
1993	19,948	11,953	1,559	1,361	3,589	1,486
1994	21,039	12,658	1,566	1,419	3,815	1,580
1995	22,101	13,331	1,655	1,492	4,024	1,599
1996 (est.)	22,908	13,744	1,715	1,589	4,205	1,655
1997 (est.)	23,811	14,186	1,799	1,685	4,404	1,737

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Appendix table 5-2.
Support for academic R&D, by sector: FYs 1960-97

	Total	Source of support				
		Federal Government	State/local government	Industry	Academic institutions	All other sources
	Millions of constant 1992 dollars[a]					
1960	2,772	1,738	365	172	275	223
1961	3,223	2,112	401	169	296	245
1962	3,781	2,564	443	167	330	276
1963	4,462	3,137	487	169	367	301
1964	5,200	3,740	538	163	420	339
1965	5,911	4,303	573	164	497	373
1966	6,730	4,948	612	165	581	424
1967	7,295	5,351	623	182	687	452
1968	7,875	5,761	630	202	799	484
1969	7,805	5,612	691	210	782	509
1970	7,781	5,488	730	203	810	550
1971	7,923	5,464	808	222	868	561
1972	7,956	5,429	815	225	922	564
1973	8,359	5,755	854	243	923	585
1974	8,178	5,498	830	260	1,000	590
1975	8,359	5,611	813	277	1,024	634
1976	8,528	5,744	832	282	1,019	651
1977	8,649	5,797	795	295	1,094	667
1978	9,197	6,083	824	337	1,238	714
1979	9,850	6,605	866	355	1,349	675
1980	10,216	6,905	827	397	1,408	679
1981	10,509	7,016	838	447	1,540	667
1982	10,499	6,836	883	483	1,593	704
1983	10,801	6,837	858	533	1,784	790
1984	11,375	7,166	911	627	1,862	809
1985	12,355	7,735	959	714	2,062	885
1986	13,556	8,326	1,135	868	2,318	909
1987	14,653	8,854	1,234	953	2,615	998
1988	15,689	9,547	1,289	1,017	2,746	1,090
1989	16,745	10,051	1,368	1,112	3,016	1,197
1990	17,477	10,342	1,421	1,210	3,226	1,279
1991	18,098	10,532	1,516	1,240	3,465	1,345
1992	18,816	11,090	1,491	1,280	3,547	1,409
1993	19,435	11,646	1,519	1,326	3,496	1,448
1994	20,030	12,051	1,491	1,350	3,633	1,505
1995	20,540	12,389	1,538	1,387	3,739	1,486
1996 (est.)	20,811	12,486	1,558	1,444	3,820	1,503
1997 (est.)	21,091	12,566	1,594	1,493	3,901	1,539

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Appendix table 5-2.

Support for academic R&D, by sector: FYs 1960-97

	Total	Federal Government	State/local government	Industry	Academic institutions	All other sources
		Percentages				
1960	100.0	62.7	13.2	6.2	9.9	8.0
1961	100.0	65.5	12.5	5.2	9.2	7.6
1962	100.0	67.8	11.7	4.4	8.7	7.3
1963	100.0	70.3	10.9	3.8	8.2	6.8
1964	100.0	71.9	10.4	3.1	8.1	6.5
1965	100.0	72.8	9.7	2.8	8.4	6.3
1966	100.0	73.5	9.1	2.4	8.6	6.3
1967	100.0	73.3	8.5	2.5	9.4	6.2
1968	100.0	73.2	8.0	2.6	10.1	6.1
1969	100.0	71.9	8.9	2.7	10.0	6.5
1970	100.0	70.5	9.4	2.6	10.4	7.1
1971	100.0	69.0	10.2	2.8	11.0	7.1
1972	100.0	68.2	10.2	2.8	11.6	7.1
1973	100.0	68.8	10.2	2.9	11.0	7.0
1974	100.0	67.2	10.2	3.2	12.2	7.2
1975	100.0	67.1	9.7	3.3	12.2	7.6
1976	100.0	67.4	9.8	3.3	11.9	7.6
1977	100.0	67.0	9.2	3.4	12.6	7.7
1978	100.0	66.1	9.0	3.7	13.5	7.8
1979	100.0	67.1	8.8	3.6	13.7	6.9
1980	100.0	67.6	8.1	3.9	13.8	6.6
1981	100.0	66.8	8.0	4.3	14.7	6.4
1982	100.0	65.1	8.4	4.6	15.2	6.7
1983	100.0	63.3	7.9	4.9	16.5	7.3
1984	100.0	63.0	8.0	5.5	16.4	7.1
1985	100.0	62.6	7.8	5.8	16.7	7.2
1986	100.0	61.4	8.4	6.4	17.1	6.7
1987	100.0	60.4	8.4	6.5	17.8	6.8
1988	100.0	60.9	8.2	6.5	17.5	6.9
1989	100.0	60.0	8.2	6.6	18.0	7.2
1990	100.0	59.2	8.1	6.9	18.5	7.3
1991	100.0	58.2	8.4	6.9	19.1	7.4
1992	100.0	58.9	7.9	6.8	18.9	7.5
1993	100.0	59.9	7.8	6.8	18.0	7.4
1994	100.0	60.2	7.4	6.7	18.1	7.5
1995	100.0	60.3	7.5	6.8	18.2	7.2
1996 (est.)	100.0	60.0	7.5	6.9	18.4	7.2
1997 (est.)	100.0	59.6	7.6	7.1	18.5	7.3

[a] See appendix table 4-1 for gross domestic product implicit price deflators used to convert current dollars to constant 1992 dollars.

SOURCES: National Science Foundation (NSF), Science Resources Studies Division, *Academic Science and Engineering R&D Expenditures: Fiscal Year 1995*, Detailed Statistical Tables, forthcoming (Arlington, VA: 1998); and NSF, annual series.

See figure 5-3.

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Appendix table 5-3.
Sources of R&D funds at private and public institutions: 1975, 1985, and 1995

Year and institution type	Total	Source of funds: Federal Government	State/local government	Industry	Academic institutions	Other sources
	Millions of current dollars					
1975						
Private, total	1,244.6	960.5	34.1	43.2	76.5	130.3
Public, total	2,164.1	1,327.5	297.6	69.8	340.9	128.3
1985						
Private, total	3,402.2	2,574.6	68.2	217.4	289.2	252.8
Public, total	6,285.0	3,489.7	683.9	342.5	1,327.8	441.0
1995						
Private, total	7,194.3	5,238.4	173.1	486.4	644.6	651.7
Public, total	14,907.0	8,092.7	1,481.9	1,006.0	3,379.1	947.3
	Percentages					
1975						
Private, total	100.0	77.2	2.7	3.5	6.1	10.5
Public, total	100.0	61.3	13.8	3.2	15.8	5.9
1985						
Private, total	100.0	75.7	2.0	6.4	8.5	7.4
Public, total	100.0	55.5	10.9	5.4	21.1	7.0
1995						
Private, total	100.0	72.8	2.4	6.8	9.0	9.1
Public, total	100.0	54.3	9.9	6.7	22.7	6.4

SOURCES: National Science Foundation (NSF), Science Resources Studies Division, *Academic Science and Engineering R&D Expenditures: Fiscal Year 1995, Detailed Statistical Tables*, forthcoming (Arlington, VA: 1998); and NSF, annual series.

Science & Engineering Indicators – 1998

Appendix table 5-4.

R&D expenditures at the top 100 academic institutions, by source of funds: 1995

(Millions of current dollars)

			Source of funds				
Rank and academic institution	Institution type	Total	Federal Government	State/ local government	Industry	Academic institutions	All other sources
Total, all institutions		22,101	13,331	1,655	1,492	4,024	1,599
1 University of Michigan, all campuses	Public	443	276	9	29	98	31
2 University of Wisconsin-Madison	Public	404	229	38	13	81	43
3 University of Washington	Public	389	291	10	37	44	7
4 Massachusetts Institute of Technology	Private	371	274	*	53	16	28
5 Texas A&M University, all campuses	Public	363	137	81	31	105	8
6 University of California-San Diego	Public	357	284	9	11	27	26
7 Cornell University, all campuses	Private	344	207	49	18	38	32
8 Johns Hopkins University[a]	Private	342	273	3	11	15	41
9 University of Minnesota, all campuses	Public	337	195	50	23	46	23
10 Pennsylvania State University, all campuses	Public	331	187	10	50	83	0
Total, top 10 institutions		3,679	2,354	259	276	553	237
11 University of California-San Francisco	Public	330	224	20	14	33	38
12 Stanford University	Private	319	273	*	16	7	21
13 University of California-Los Angeles	Public	304	202	4	15	41	42
14 University of Arizona	Public	292	169	6	15	93	9
15 University of California-Berkeley	Public	291	158	29	14	71	20
16 Harvard University	Private	276	204	*	8	13	51
17 University of Pennsylvania	Private	272	201	5	12	24	30
18 University of Colorado, all campuses	Public	250	170	4	13	29	33
19 Ohio State University, all campuses	Public	246	123	28	22	39	35
20 University of Illinois at Urbana-Champaign	Public	246	139	29	12	54	12
Total, top 20 institutions		6,506	4,216	384	418	958	528
21 Columbia University in the City of New York	Private	245	206	2	1	8	27
22 University of California-Davis	Public	244	123	18	8	77	19
23 Yale University	Private	232	175	3	14	16	24
24 University of Texas at Austin	Public	229	144	11	3	51	19
25 University of Southern California	Private	222	164	7	18	34	0
26 Duke University	Private	219	149	5	33	16	17
27 Georgia Institute of Technology, all campuses	Public	212	105	6	26	75	0
28 University of Maryland at College Park	Public	210	94	55	25	36	0
29 University of North Carolina at Chapel Hill	Public	209	157	24	2	26	0
30 Washington University	Private	209	147	5	22	15	21
Total, top 30 institutions		8,737	5,678	520	571	1,312	655
31 University of Georgia	Public	206	58	40	11	97	1
32 Purdue University, all campuses	Public	203	93	19	25	65	*
33 Rutgers the State University of NJ, all campuses	Public	192	73	26	8	73	12
34 Baylor College of Medicine	Private	190	94	5	12	24	55
35 Louisiana State University, all campuses	Public	187	61	64	10	37	14
36 University of Pittsburgh, all campuses	Public	186	144	4	8	17	13
37 North Carolina State University at Raleigh	Public	180	69	67	26	17	*
38 Northwestern University	Private	174	90	3	7	55	18
39 University of Iowa	Public	165	103	5	11	35	11
40 Michigan State University	Public	163	74	27	7	42	12
Total, top 40 institutions		10,584	6,538	780	697	1,774	791

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Appendix table 5-4.

R&D expenditures at the top 100 academic institutions, by source of funds: 1995

(Millions of current dollars)

			Source of funds				
Rank and academic institution	Institution type	Total	Federal Government	State/ local government	Industry	**Academic institutions**	All other sources
41 University of Alabama at Birmingham	Public	159	107	4	19	11	17
42 University of Rochester	Private	159	126	9	13	3	8
43 Iowa State University	Public	155	59	42	8	42	4
44 University of Florida	Public	154	79	11	11	47	6
45 University of Tennessee University-Wide Administrative Central Office	Public	151	76	27	11	28	10
46 New York University	Private	149	94	2	6	18	29
47 Virginia Polytechnic Institute and State University	Public	149	79	33	12	21	3
48 Emory University	Private	148	93	4	11	19	21
49 Indiana University, all campuses	Public	146	85	2	6	32	20
50 SUNY at Buffalo, all campuses	Public	144	76	12	13	16	27
Total, top 50 institutions		12,097	7,413	925	807	2,012	936
51 Case Western Reserve University	Private	141	107	4	5	12	12
52 University of Connecticut, all campuses	Public	140	50	15	7	61	7
53 California Institute of Technology	Private	138	121	*	5	9	2
54 University of Virginia, all campuses	Public	137	85	5	15	14	16
55 University of New Mexico, all campuses	Public	129	91	4	3	26	5
56 University of Miami	Private	129	97	2	12	6	12
57 University of Chicago	Private	126	105	1	2	8	11
58 Carnegie Mellon University	Private	126	85	8	18	5	10
59 University of Texas Southwestern Medical Center Dallas	Public	125	79	*	15	6	25
60 Oregon State University	Public	123	69	28	3	14	9
Total, top 60 institutions		13,411	8,301	993	893	2,174	1,047
61 University of Missouri, Columbia	Public	123	32	15	10	58	7
62 SUNY at Stony Brook, all campuses	Public	123	77	3	6	31	7
63 University of Texas MD Anderson Cancer Center	Public	122	45	0	0	50	28
64 Colorado State University	Public	122	75	17	6	22	2
65 University of Illinois at Chicago	Public	119	58	3	6	41	12
66 University of Kentucky, all campuses	Public	112	50	9	12	36	5
67 Vanderbilt University	Private	111	92	*	3	9	7
68 University of California-Irvine	Public	110	70	4	9	15	12
69 University of Maryland at Baltimore	Public	108	60	15	18	6	9
70 University of Nebraska at Lincoln	Public	108	37	34	3	33	*
Total, top 70 institutions		14,569	8,895	1,093	966	2,474	1,135
71 Wayne State University	Public	106	46	9	8	32	11
72 University of Utah	Public	106	84	*	4	11	6
73 Princeton University	Private	104	64	*	6	24	10
74 Boston University	Private	104	83	*	9	0	11
75 Georgetown University	Private	102	74	*	6	15	7
76 University of Oklahoma, all campuses	Public	102	37	11	6	35	14
77 University of Kansas, all campuses	Public	101	42	8	8	37	5
78 Tulane University	Private	100	61	4	10	22	3
79 Washington State University	Public	97	49	4	3	33	9
80 University of Medicine and Dentistry of New Jersey	Public	96	46	6	8	26	11
Total, top 80 institutions		15,588	9,482	1,135	1,034	2,708	1,222

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Appendix table 5-4.

R&D expenditures at the top 100 academic institutions, by source of funds: 1995

(Millions of current dollars)

			Source of funds				
Rank and academic institution	Institution type	Total	Federal Govern-ment	State/ local government	Industry	Academic institutions	All other sources
81 Yeshiva University	Private	95	72	0	2	12	9
82 Auburn University, all campuses	Public	93	28	*	3	57	4
83 University of South Florida	Public	93	30	8	5	45	6
84 Mount Sinai School of Medicine	Private	92	59	3	6	11	13
85 University of Cincinnati, all campuses	Public	91	55	3	9	19	6
86 University of Texas Health Science Center San Antonio	Public	87	54	9	9	11	4
87 Florida State University	Public	86	46	3	2	31	4
88 Clemson University	Public	83	29	15	5	29	4
89 Utah State University	Public	82	48	14	3	15	2
90 New Mexico State University, all campuses	Public	81	57	12	2	8	2
Total, top 90 institutions		16,471	9,960	1,200	1,080	2,946	1,276
91 Woods Hole Oceanographic Institution	Private	80	73	*	0	1	6
92 University of South Carolina, all campuses	Public	80	44	3	8	22	3
93 University of California-Santa Barbara	Public	79	63	1	3	7	5
94 University of Hawaii at Manoa	Public	78	44	27	0	4	3
95 Rockefeller University	Private	77	41	*	4	17	14
96 Tufts University	Private	77	50	2	5	14	6
97 Arizona State University, main	Public	77	35	*	7	31	3
98 Virginia Commonwealth University	Public	77	47	2	6	18	4
99 Oklahoma State University, all campuses	Public	76	19	8	3	43	3
100 Oregon Health Sciences University	Public	75	49	*	5	16	4
Total, top 100 institutions		17,247	10,427	1,243	1,121	3,120	1,326

* = less than $1 million

[a] These figures exclude the Applied Physics Laboratory (APL) at Johns Hopkins University, which is similar to a federally funded research and development center and dominates the R&D performed at the university. In 1995, APL had total R&D expenditures of $447 million, of which $434 million were provided by federal sources.

SOURCES: National Science Foundation (NSF), Science Resources Studies Division, *Academic Science and Engineering R&D Expenditures: Fiscal Year 1995, Detailed Statistical Tables*, forthcoming (Arlington, VA: 1998); and NSF, unpublished tabulations.

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Appendix table 5-5.

Total, federal, and nonfederal R&D expenditures at academic institutions, by field and source of funds: 1995

	Total R&D		Millions of dollars		Percentages	
Field	Millions of dollars	Percent	Federal	Non-federal[a]	Federal	Non-federal[a]
TOTAL SCIENCE & ENGINEERING	22,101.2	100.0	13,331.2	8,770.1	60.3	39.7
Total sciences	18,556.0	84.0	11,196.4	7,359.6	60.3	39.7
Physical sciences	2,241.4	10.1	1,631.5	609.9	72.8	27.2
Astronomy	307.4	1.4	208.6	98.8	67.9	32.1
Chemistry	773.1	3.5	535.0	238.1	69.2	30.8
Physics	969.0	4.4	750.6	218.3	77.5	22.5
Other	192.0	0.9	137.3	54.7	71.5	28.5
Mathematics	283.6	1.3	206.0	77.6	72.6	27.4
Computer sciences	679.7	3.1	477.7	202.0	70.3	29.7
Environmental sciences	1,434.2	6.5	962.1	472.1	67.1	32.9
Atmospheric sciences	208.2	0.9	163.5	44.7	78.5	21.5
Earth sciences	460.4	2.1	269.1	191.3	58.5	41.5
Oceanography	481.1	2.2	338.3	142.7	70.3	29.7
Other	284.5	1.3	191.1	93.4	67.2	32.8
Life sciences	12,133.2	54.9	7,119.7	5,013.5	58.7	41.3
Agricultural sciences	1,734.2	7.8	526.8	1,207.4	30.4	69.6
Biological sciences	3,835.7	17.4	2,492.9	1,342.7	65.0	35.0
Medical sciences	6,057.2	27.4	3,807.3	2,249.9	62.9	37.1
Other	506.1	2.3	292.7	213.4	57.8	42.2
Psychology	370.2	1.7	250.0	120.2	67.5	32.5
Social sciences	1,018.4	4.6	391.9	626.5	38.5	61.5
Economics	244.1	1.1	79.0	165.1	32.4	67.6
Political science	177.0	0.8	63.7	113.3	36.0	64.0
Sociology	216.3	1.0	105.2	111.1	48.6	51.4
Other	380.9	1.7	143.9	237.0	37.8	62.2
Other sciences	395.4	1.8	157.6	237.8	39.9	60.1
Total engineering	3,545.2	16.0	2,134.7	1,410.5	60.2	39.8
Aeronautical/astronautical	227.5	1.0	170.8	56.6	75.1	24.9
Chemical	296.2	1.3	160.9	135.3	54.3	45.7
Civil	427.9	1.9	184.5	243.4	43.1	56.9
Electrical/electronic	790.1	3.6	518.0	272.1	65.6	34.4
Mechanical	508.9	2.3	329.1	179.8	64.7	35.3
Materials	325.7	1.5	171.6	154.1	52.7	47.3
Other	968.9	4.4	599.7	369.2	61.9	38.1

[a] See appendix table 5-2 for detail on nonfederal sources.

SOURCES: National Science Foundation (NSF), Science Resources Studies Division, *Academic Science and Engineering R&D Expenditures: Fiscal Year 1995*, Detailed Statistical Tables, forthcoming (Arlington, VA: 1998); and NSF, unpublished tabulations.

Science & Engineering Indicators – 1998

Appendix table 5-6.

Expenditures for academic R&D, by field: 1985-95

Field	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
					Millions of current dollars						
TOTAL SCIENCE & ENGINEERING	9,687	10,928	12,153	13,463	14,976	16,285	17,584	18,816	19,948	21,039	22,101
Total sciences	8,269	9,287	10,261	11,367	12,584	13,629	14,677	15,754	16,793	17,691	18,556
Physical sciences	1,148	1,287	1,398	1,554	1,647	1,807	1,939	2,055	2,130	2,174	2,241
Astronomy	96	102	108	127	137	170	211	238	259	269	307
Chemistry	422	470	514	565	606	648	671	704	740	761	773
Physics	551	631	673	740	786	842	881	921	940	951	969
Other	80	85	103	122	117	147	176	191	191	193	192
Mathematics	128	152	177	199	215	222	230	248	272	282	284
Computer sciences	281	321	372	408	473	515	554	556	608	650	680
Environmental sciences	705	776	839	894	1,003	1,068	1,117	1,240	1,317	1,407	1,434
Atmospheric sciences	108	121	132	138	165	173	175	194	210	207	208
Earth sciences	254	274	284	294	324	354	384	413	416	459	460
Oceanography	258	280	299	333	359	377	390	428	459	455	481
Other	86	101	123	128	156	163	169	205	232	285	284
Life sciences	5,279	5,891	6,529	7,257	8,061	8,726	9,472	10,196	10,851	11,493	12,133
Agricultural sciences	999	1,089	1,121	1,176	1,282	1,349	1,458	1,512	1,559	1,661	1,734
Biological sciences	1,781	1,946	2,144	2,408	2,640	2,859	3,064	3,303	3,535	3,733	3,836
Medical sciences	2,318	2,615	3,000	3,377	3,819	4,154	4,546	4,964	5,323	5,637	6,057
Other	181	240	264	296	321	363	404	417	433	462	506
Psychology	158	170	187	213	234	253	283	328	350	357	370
Social sciences	383	462	502	552	633	703	750	815	896	951	1,018
Economics	118	136	149	163	187	201	209	222	231	241	244
Political science	59	69	81	87	103	115	125	142	151	162	177
Sociology	75	96	95	108	119	132	156	163	183	195	216
Other	131	162	177	194	224	255	260	288	331	352	381
Other sciences	186	228	256	290	318	336	332	315	368	378	395
Total engineering	1,418	1,641	1,892	2,096	2,392	2,656	2,907	3,062	3,155	3,348	3,545
Aeronautical/astronautical	81	94	108	123	148	163	180	196	212	220	227
Chemical	116	132	148	163	194	218	244	261	274	280	296
Civil	153	178	191	224	245	284	315	339	371	401	428
Electrical/electronic	337	395	451	509	595	663	679	704	698	742	790
Mechanical	208	228	275	304	343	391	421	451	483	499	509
Materials	NA	NA	NA	NA	NA	274	304	294	299	310	326
Other	523	613	719	774	867	663	764	817	818	897	969

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Appendix table 5-6.

Expenditures for academic R&D, by field: 1985-95

Field	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
					Millions of constant 1992 dollars[a]						
TOTAL SCIENCE & ENGINEERING	12,355	13,556	14,653	15,689	16,745	17,477	18,098	18,816	19,435	20,030	20,540
Total sciences	10,547	11,521	12,372	13,246	14,070	14,626	15,107	15,754	16,361	16,842	17,245
Physical sciences	1,465	1,596	1,686	1,811	1,842	1,939	1,995	2,055	2,075	2,070	2,083
Astronomy	123	126	131	148	154	183	217	238	252	256	286
Chemistry	538	583	619	659	678	695	690	704	721	724	718
Physics	703	782	812	862	879	903	907	921	916	905	901
Other	102	105	124	143	131	158	181	191	186	184	178
Mathematics	163	188	214	232	240	238	237	248	265	269	264
Computer sciences	358	399	449	476	528	552	571	556	593	619	632
Environmental sciences	900	963	1,011	1,042	1,122	1,146	1,150	1,240	1,283	1,339	1,333
Atmospheric sciences	138	150	160	161	185	186	180	194	205	197	193
Earth sciences	324	340	342	343	362	380	395	413	406	437	428
Oceanography	329	347	361	388	401	405	401	428	447	433	447
Other	109	126	149	150	174	175	174	205	226	272	264
Life sciences	6,733	7,308	7,872	8,457	9,013	9,364	9,749	10,196	10,571	10,942	11,276
Agricultural sciences	1,274	1,351	1,351	1,371	1,433	1,448	1,501	1,512	1,519	1,581	1,612
Biological sciences	2,272	2,415	2,585	2,806	2,951	3,068	3,153	3,303	3,444	3,554	3,565
Medical sciences	2,957	3,244	3,617	3,936	4,270	4,458	4,680	4,964	5,186	5,367	5,629
Other	231	297	318	345	359	390	415	417	422	440	470
Psychology	202	211	226	248	261	271	291	328	341	340	344
Social sciences	489	574	606	643	708	755	772	815	873	905	946
Economics	151	168	180	190	209	215	215	222	225	230	227
Political science	76	85	98	101	116	124	129	142	147	154	165
Sociology	95	119	115	126	133	141	160	163	179	186	201
Other	167	201	213	226	250	274	268	288	322	335	354
Other sciences	238	283	309	337	356	360	341	315	359	359	367
Total engineering	1,808	2,035	2,281	2,443	2,675	2,851	2,992	3,062	3,074	3,188	3,295
Aeronautical/astronautical	103	117	130	143	166	175	185	196	207	210	211
Chemical	148	164	179	189	217	234	251	261	267	266	275
Civil	195	221	230	261	274	305	324	339	362	382	398
Electrical/electronic	430	490	544	593	665	711	699	704	680	706	734
Mechanical	265	283	331	354	384	419	433	451	470	475	473
Materials	NA	NA	NA	NA	NA	294	313	294	291	295	303
Other	667	761	867	902	970	712	786	817	797	854	900

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Appendix table 5-6.
Expenditures for academic R&D, by field: 1985-95

Field	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
					Percentages						
TOTAL SCIENCE & ENGINEERING	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total sciences	85.4	85.0	84.4	84.4	84.0	83.7	83.5	83.7	84.2	84.1	84.0
Physical sciences	11.9	11.8	11.5	11.5	11.0	11.1	11.0	10.9	10.7	10.3	10.1
Astronomy	1.0	0.9	0.9	0.9	0.9	1.0	1.2	1.3	1.3	1.3	1.4
Chemistry	4.4	4.3	4.2	4.2	4.0	4.0	3.8	3.7	3.7	3.6	3.5
Physics	5.7	5.8	5.5	5.5	5.2	5.2	5.0	4.9	4.7	4.5	4.4
Other	0.8	0.8	0.8	0.9	0.8	0.9	1.0	1.0	1.0	0.9	0.9
Mathematics	1.3	1.4	1.5	1.5	1.4	1.4	1.3	1.3	1.4	1.3	1.3
Computer sciences	2.9	2.9	3.1	3.0	3.2	3.2	3.2	3.0	3.1	3.1	3.1
Environmental sciences	7.3	7.1	6.9	6.6	6.7	6.6	6.4	6.6	6.6	6.7	6.5
Atmospheric sciences	1.1	1.1	1.1	1.0	1.1	1.1	1.0	1.0	1.1	1.0	0.9
Earth sciences	2.6	2.5	2.3	2.2	2.2	2.2	2.2	2.2	2.1	2.2	2.1
Oceanography	2.7	2.6	2.5	2.5	2.4	2.3	2.2	2.3	2.3	2.2	2.2
Other	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.1	1.2	1.4	1.3
Life sciences	54.5	53.9	53.7	53.9	53.8	53.6	53.9	54.2	54.4	54.6	54.9
Agricultural sciences	10.3	10.0	9.2	8.7	8.6	8.3	8.3	8.0	7.8	7.9	7.8
Biological sciences	18.4	17.8	17.6	17.9	17.6	17.6	17.4	17.6	17.7	17.7	17.4
Medical sciences	23.9	23.9	24.7	25.1	25.5	25.5	25.9	26.4	26.7	26.8	27.4
Other	1.9	2.2	2.2	2.2	2.1	2.2	2.3	2.2	2.2	2.2	2.3
Psychology	1.6	1.6	1.5	1.6	1.6	1.6	1.6	1.7	1.8	1.7	1.7
Social sciences	4.0	4.2	4.1	4.1	4.2	4.3	4.3	4.3	4.5	4.5	4.6
Economics	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1
Political science	0.6	0.6	0.7	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.8
Sociology	0.8	0.9	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0
Other	1.4	1.5	1.5	1.4	1.5	1.6	1.5	1.5	1.7	1.7	1.7
Other sciences	1.9	2.1	2.1	2.2	2.1	2.1	1.9	1.7	1.8	1.8	1.8
Total engineering	14.6	15.0	15.6	15.6	16.0	16.3	16.5	16.3	15.8	15.9	16.0
Aeronautical/astronautical	0.8	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.1	1.0	1.0
Chemical	1.2	1.2	1.2	1.2	1.3	1.3	1.4	1.4	1.4	1.3	1.3
Civil	1.6	1.6	1.6	1.7	1.6	1.7	1.8	1.8	1.9	1.9	1.9
Electrical/electronic	3.5	3.6	3.7	3.8	4.0	4.1	3.9	3.7	3.5	3.5	3.6
Mechanical	2.1	2.1	2.3	2.3	2.3	2.4	2.4	2.4	2.4	2.4	2.3
Materials	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other	5.4	5.6	5.9	5.8	5.8	4.1	4.3	4.3	4.1	4.3	4.4

NA = not available

[a] See appendix table 4-1 for gross domestic product implicit price deflators used to convert current dollars to constant 1992 dollars.

SOURCES: National Science Foundation (NSF), Science Resources Studies Division, *Academic Science and Engineering R&D Expenditures: Fiscal Year 1995*, Detailed Statistical Tables, forthcoming (Arlington, VA: 1998); and NSF, unpublished tabulations.

See figure 5-4.

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Appendix table 5-7.

Percentage of academic R&D funds federally financed, by field: 1975-95

Field	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
TOTAL S&E	67.1	67.4	67.0	66.1	67.1	67.6	66.8	65.1	63.3	63.0	62.6	61.4	60.4	60.9	60.0	59.2	58.2	58.9	59.9	60.2	60.3
Total sciences	67.0	67.4	67.0	65.9	66.8	67.4	66.5	64.8	62.9	62.8	62.8	61.7	60.7	61.3	60.4	59.5	58.6	59.3	60.1	60.3	60.3
Physical sciences	81.4	80.5	80.0	79.0	81.5	81.9	80.8	78.9	77.7	78.1	77.5	76.4	75.2	74.5	72.7	72.8	71.4	71.8	71.0	71.9	72.8
Astronomy	73.4	69.8	71.8	71.6	74.8	75.6	71.0	70.6	68.0	66.1	67.0	68.5	65.7	66.1	64.0	66.1	64.4	66.5	63.8	67.6	67.9
Chemistry	76.8	77.0	76.2	75.4	75.8	77.7	76.0	74.7	73.8	75.1	74.2	72.1	71.7	71.3	69.6	68.7	67.3	68.1	68.2	68.3	69.2
Physics	86.4	85.3	85.2	84.7	86.5	86.8	86.4	83.5	82.1	82.3	82.2	80.9	79.4	78.4	77.1	77.5	77.1	76.9	75.3	76.2	77.5
Other	77.7	77.2	73.7	69.7	82.7	78.7	81.1	81.2	80.5	80.1	75.1	75.8	75.1	74.7	69.5	71.8	66.4	67.7	70.3	70.8	71.5
Mathematics	78.6	77.4	77.7	75.1	77.6	78.4	77.8	74.5	71.9	75.0	75.9	75.5	74.4	75.4	73.3	72.6	74.1	74.0	74.6	72.9	72.6
Computer sci.	74.3	74.0	67.6	61.1	70.9	70.4	72.4	74.2	74.6	72.7	69.7	72.4	69.1	70.8	68.5	66.5	67.0	68.3	69.6	71.3	70.3
Environmental sci.	70.8	73.4	74.7	72.5	72.6	73.1	71.1	70.1	69.1	69.1	67.2	66.6	65.0	65.9	64.8	63.8	62.7	63.7	66.0	67.4	67.1
Atmospheric sci.	NA	NA	NA	NA	NA	84.1	77.0	79.9	78.4	80.7	79.8	81.2	82.0	81.2	77.9	75.7	74.1	72.1	76.3	79.6	78.5
Earth sci.	NA	NA	NA	NA	NA	69.7	67.1	64.9	62.4	61.4	60.7	58.3	56.2	59.3	57.7	57.7	56.7	57.7	58.4	58.6	58.5
Oceanography	NA	NA	NA	NA	NA	77.6	77.9	77.4	76.6	76.4	72.7	74.3	72.6	71.6	72.5	69.4	67.6	71.6	71.8	71.1	70.3
Other	70.8	73.4	74.7	72.5	72.6	59.1	58.0	53.5	54.2	54.0	53.9	50.3	48.9	49.8	48.1	51.0	52.9	51.6	58.6	67.0	67.2
Life sciences	65.1	65.7	65.3	64.1	64.1	64.9	64.0	62.4	60.2	60.1	60.4	59.3	58.8	59.6	59.3	58.3	57.2	58.0	58.9	58.7	58.7
Agricultural sci.	29.4	29.7	28.8	29.8	30:2	30.9	29.7	29.5	28.4	28.2	29.4	26.8	26.6	27.4	27.3	26.1	25.9	27.6	28.9	29.9	30.4
Biological sci.	72.5	73.5	74.5	73.0	72.6	74.0	73.0	71.4	69.5	69.5	67.9	67.4	66.2	66.8	65.8	64.5	63.7	64.7	65.3	65.6	65.0
Medical sci.	75.6	75.5	74.9	73.1	73.7	74.4	74.1	72.0	68.9	67.6	68.0	66.6	65.4	65.5	65.5	64.3	62.7	62.7	63.3	62.7	62.9
Other	71.8	72.6	71.7	70.4	70.1	67.3	67.5	64.0	61.0	62.9	60.0	61.3	59.8	61.7	61.0	59.1	60.0	58.2	59.3	58.7	57.8
Psychology	76.8	76.2	74.8	71.4	72.3	73.3	72.7	68.1	66.0	67.4	66.9	67.0	66.1	65.9	65.5	64.8	65.8	65.4	67.0	67.6	67.5
Social sciences	55.2	52.7	51.6	50.6	53.0	53.8	51.0	45.6	42.6	39.8	40.1	37.4	33.6	34.2	33.5	32.2	33.7	34.5	37.7	37.8	38.5
Economics	48.2	44.5	43.8	46.9	48.4	48.8	45.4	43.7	39.6	39.1	37.0	33.5	29.1	30.2	29.1	27.1	28.6	29.8	33.4	31.5	32.4
Political science	41.8	42.2	46.2	43.4	46.0	43.4	42.0	37.3	36.8	33.9	33.1	29.4	29.7	29.0	25.0	22.0	22.8	24.7	28.3	31.0	36.0
Sociology	65.5	62.1	61.1	60.7	63.4	65.0	60.5	58.5	55.3	54.0	53.5	51.2	46.2	44.1	45.2	45.5	46.3	50.0	49.7	49.5	48.6
Other	55.9	54.8	52.9	49.4	52.2	54.1	52.3	42.8	39.3	35.3	38.5	35.8	32.4	34.4	34.9	33.9	35.5	34.2	38.5	38.7	37.8
Other sciences	57.2	59.5	54.9	58.1	54.9	53.6	56.5	56.5	52.7	48.5	49.3	47.1	44.8	41.9	40.1	41.1	33.8	32.4	35.1	36.2	39.9
Total engineering	68.1	67.3	67.6	67.8	68.7	68.6	68.5	67.2	65.5	64.0	61.2	59.6	58.8	58.7	57.8	57.4	56.3	57.2	58.9	59.4	60.2
Aeronautical/ astronautical	NA	NA	NA	NA	NA	79.5	80.0	79.1	78.7	78.2	76.4	77.0	74.1	76.3	77.5	77.7	76.4	76.7	75.1	75.4	75.1
Chemical	NA	NA	NA	NA	NA	64.4	66.9	62.0	59.5	59.1	55.6	55.4	51.7	52.6	52.1	50.6	48.4	48.4	52.2	53.7	54.3
Civil	NA	NA	NA	NA	NA	64.0	56.8	51.5	50.4	51.8	51.5	49.6	47.0	45.6	41.7	41.2	39.3	42.3	41.6	40.7	43.1
Electrical/ electronic	NA	NA	NA	NA	NA	75.7	75.9	77.1	73.8	71.0	67.7	65.9	64.8	64.9	65.0	65.1	64.2	63.9	65.7	65.9	65.6
Mechanical	NA	NA	NA	NA	NA	67.0	67.5	68.3	67.1	66.5	64.6	64.9	64.9	63.5	62.4	61.0	59.7	59.7	64.2	65.2	64.7
Materials	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	50.9	50.4	48.7	50.3	49.9	52.7
Other	68.1	67.3	67.6	67.8	68.7	65.7	67.3	65.3	63.5	61.1	57.3	54.6	55.0	54.9	53.6	54.6	54.8	57.5	58.9	60.3	61.9

NA = not available

SOURCES: National Science Foundation (NSF), Science Resources Studies Division, *Academic Science and Engineering R&D Expenditures: Fiscal Year 1995*, Detailed Statistical Tables, forthcoming (Arlington, VA: 1998); and NSF, unpublished tabulations.

Science & Engineering Indicators – 1998

Appendix table 5-8.

Federal obligations for academic R&D, by agency: 1971-97

	All agencies	National Institutes of Health	National Science Foundation	Department of Defense	National Aeronautics & Space Administration	Department of Energy[a]	Department of Agriculture	All other agencies
Millions of current dollars								
1971	1,645	603	267	211	134	94	72	264
1972	1,904	756	362	217	119	85	87	277
1973	1,917	826	374	204	111	83	94	224
1974	2,214	1,108	389	197	99	94	95	232
1975	2,411	1,154	435	203	108	132	108	271
1976	2,552	1,263	437	240	119	145	120	228
1977	2,905	1,399	511	273	118	188	140	276
1978	3,375	1,588	537	383	127	240	186	313
1979	3,889	1,880	617	438	139	260	200	355
1980	4,263	2,012	685	495	158	285	216	412
1981	4,466	2,101	702	573	171	301	243	375
1982	4,605	2,140	715	664	186	277	255	369
1983	4,966	2,392	783	724	189	297	275	306
1984	5,547	2,715	880	830	204	321	261	335
1985	6,340	3,158	1,002	940	237	357	293	352
1986	6,559	3,243	992	1,098	254	345	274	355
1987	7,337	3,903	1,096	1,017	294	386	280	361
1988	7,828	4,199	1,143	1,071	338	406	305	366
1989	8,672	4,565	1,254	1,189	434	454	328	449
1990	9,138	4,779	1,321	1,213	471	500	348	505
1991	10,169	5,521	1,436	1,152	534	621	386	520
1992	10,271	5,064	1,540	1,403	586	640	438	600
1993	11,208	5,848	1,562	1,616	614	583	433	553
1994	11,829	6,191	1,680	1,735	641	565	439	577
1995	11,933	6,271	1,734	1,592	708	594	435	599
1996 (est.)	12,251	6,908	1,726	1,380	708	557	423	549
1997 (est.)	12,362	6,987	1,824	1,288	708	574	421	561
Millions of constant 1992 dollars[b]								
1971	5,214	1,911	846	669	425	298	228	837
1972	5,758	2,287	1,096	656	360	256	265	838
1973	5,555	2,394	1,085	590	323	240	273	650
1974	5,990	2,997	1,053	534	268	254	256	627
1975	5,914	2,829	1,066	499	265	324	265	666
1976	5,836	2,888	998	550	272	332	274	522
1977	6,179	2,975	1,086	581	250	400	298	588
1978	6,711	3,157	1,068	762	253	477	371	623
1979	7,138	3,452	1,132	804	255	477	367	652
1980	7,184	3,390	1,154	835	266	480	365	695
1981	6,854	3,224	1,078	879	263	462	373	576
1982	6,602	3,068	1,025	951	266	397	366	529
1983	6,806	3,277	1,073	992	259	407	377	420
1984	7,320	3,583	1,162	1,095	269	423	344	443
1985	8,086	4,027	1,278	1,199	303	456	374	450
1986	8,136	4,022	1,230	1,362	315	428	339	440
1987	8,847	4,706	1,322	1,226	354	466	337	435
1988	9,122	4,893	1,332	1,248	394	473	355	426
1989	9,696	5,105	1,402	1,329	485	507	367	502
1990	9,806	5,129	1,418	1,302	505	537	374	542
1991	10,466	5,683	1,478	1,186	549	639	397	535
1992	10,271	5,064	1,540	1,403	586	640	438	600
1993	10,920	5,697	1,522	1,574	598	568	422	539
1994	11,262	5,895	1,600	1,652	611	538	418	549
1995	11,090	5,828	1,611	1,480	658	552	404	557
1996 (est.)	11,130	6,276	1,568	1,253	643	506	384	499
1997 (est.)	10,950	6,189	1,615	1,141	627	509	373	497

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Appendix table 5-8.

Federal obligations for academic R&D, by agency: 1971-97

	All agencies	National Institutes of Health	National Science Foundation	Department of Defense	National Aeronautics & Space Administration	Department of Energy[a]	Department of Agriculture	All other agencies
	Percentages by agency							
1971	100.0	36.7	16.2	12.8	8.1	5.7	4.4	16.0
1972	100.0	39.7	19.0	11.4	6.3	4.4	4.6	14.6
1973	100.0	43.1	19.5	10.6	5.8	4.3	4.9	11.7
1974	100.0	50.0	17.6	8.9	4.5	4.2	4.3	10.5
1975	100.0	47.8	18.0	8.4	4.5	5.5	4.5	11.3
1976	100.0	49.5	17.1	9.4	4.7	5.7	4.7	8.9
1977	100.0	48.2	17.6	9.4	4.0	6.5	4.8	9.5
1978	100.0	47.0	15.9	11.4	3.8	7.1	5.5	9.3
1979	100.0	48.4	15.9	11.3	3.6	6.7	5.1	9.1
1980	100.0	47.2	16.1	11.6	3.7	6.7	5.1	9.7
1981	100.0	47.0	15.7	12.8	3.8	6.7	5.4	8.4
1982	100.0	46.5	15.5	14.4	4.0	6.0	5.5	8.0
1983	100.0	48.2	15.8	14.6	3.8	6.0	5.5	6.2
1984	100.0	49.0	15.9	15.0	3.7	5.8	4.7	6.0
1985	100.0	49.8	15.8	14.8	3.7	5.6	4.6	5.6
1986	100.0	49.4	15.1	16.7	3.9	5.3	4.2	5.4
1987	100.0	53.2	14.9	13.9	4.0	5.3	3.8	4.9
1988	100.0	53.6	14.6	13.7	4.3	5.2	3.9	4.7
1989	100.0	52.6	14.5	13.7	5.0	5.2	3.8	5.2
1990	100.0	52.3	14.5	13.3	5.2	5.5	3.8	5.5
1991	100.0	54.3	14.1	11.3	5.2	6.1	3.8	5.1
1992	100.0	49.3	15.0	13.7	5.7	6.2	4.3	5.8
1993	100.0	52.2	13.9	14.4	5.5	5.2	3.9	4.9
1994	100.0	52.3	14.2	14.7	5.4	4.8	3.7	4.9
1995	100.0	52.6	14.5	13.3	5.9	5.0	3.6	5.0
1996 (est.)	100.0	56.4	14.1	11.3	5.8	4.5	3.5	4.5
1997 (est.)	100.0	56.5	14.8	10.4	5.7	4.6	3.4	4.5

NOTE: Percentages may not total 100 because of rounding.

[a] Data for 1974 to 1976 are for the Energy Research and Development Administration; data for 1977 and thereafter are for the U.S. Department of Energy.

[b] See appendix table 4-1 for gross domestic product implicit price deflators used to convert current dollars to constant 1992 dollars.

SOURCES: National Science Foundation (NSF), Science Resources Studies Division, *Federal Funds for Research and Development: Fiscal Years 1995, 1996, and 1997*, Detailed Statistical Tables, Vol. 45, NSF 97-327 (Arlington, VA: 1997); and NSF, annual series.

Appendix table 5-9.

Federal obligations for academic research, by agency: 1971-97

	All agencies	National Institutes of Health	National Science Foundation	Department of Defense	National Aeronautics & Space Administration	Department of Energy[a]	Department of Agriculture	All other agencies
				Millions of current dollars				
1971	1,430	551	254	184	70	90	72	209
1972	1,643	677	346	177	48	81	87	226
1973	1,691	749	370	161	80	79	94	158
1974	1,958	1,004	369	167	85	86	94	153
1975	2,079	1,036	420	165	91	112	108	148
1976	2,250	1,138	429	192	98	116	119	158
1977	2,584	1,269	505	221	105	134	139	211
1978	2,928	1,437	534	243	116	175	181	241
1979	3,333	1,657	612	271	125	204	198	266
1980	3,699	1,835	680	313	146	224	214	287
1981	3,920	1,929	698	363	157	248	240	284
1982	4,045	1,995	713	413	156	236	253	280
1983	4,468	2,246	783	472	170	273	273	250
1984	5,030	2,573	880	539	177	311	260	290
1985	5,726	2,990	1,002	587	213	336	292	305
1986	5,883	3,054	992	707	225	334	273	298
1987	6,640	3,651	1,096	681	263	372	279	298
1988	7,023	3,856	1,143	729	310	384	304	297
1989	7,793	4,167	1,254	840	387	437	326	382
1990	8,137	4,349	1,321	795	422	479	346	426
1991	8,868	4,729	1,436	794	474	596	384	456
1992	9,061	4,517	1,540	912	512	605	436	538
1993	9,844	5,204	1,562	1,090	539	547	429	473
1994	10,323	5,517	1,680	1,111	555	529	435	496
1995	10,372	5,481	1,734	1,063	588	558	431	518
1996 (est.)	10,920	6,163	1,726	1,026	588	526	419	472
1997 (est.)	10,823	6,033	1,824	968	588	533	417	461
				Millions of constant 1992 dollars[b]				
1971	4,532	1,746	805	583	222	285	228	662
1972	4,969	2,048	1,047	535	145	245	263	684
1973	4,902	2,171	1,072	467	232	229	272	458
1974	5,297	2,716	998	452	230	233	254	414
1975	5,098	2,541	1,030	405	223	275	265	363
1976	5,146	2,603	981	439	224	265	272	361
1977	5,495	2,699	1,074	470	223	285	296	449
1978	5,823	2,858	1,062	483	231	348	360	479
1979	6,118	3,042	1,123	497	229	374	363	488
1980	6,233	3,092	1,146	527	246	377	361	484
1981	6,016	2,961	1,071	557	241	381	368	436
1982	5,799	2,860	1,022	592	224	338	363	401
1983	6,123	3,078	1,073	647	233	374	374	343
1984	6,638	3,395	1,161	711	234	410	343	383
1985	7,303	3,814	1,278	749	272	429	372	389
1986	7,298	3,789	1,231	877	279	414	339	370
1987	8,006	4,402	1,321	821	317	449	336	359
1988	8,184	4,494	1,332	850	361	447	354	346
1989	8,714	4,659	1,402	939	433	489	365	427
1990	8,732	4,667	1,418	853	453	514	371	457
1991	9,128	4,867	1,478	817	488	613	395	469
1992	9,061	4,517	1,540	912	512	605	436	538
1993	9,591	5,070	1,522	1,062	525	533	418	461
1994	9,828	5,252	1,599	1,058	528	504	414	472
1995	9,639	5,094	1,611	988	546	519	400	481
1996 (est.)	9,920	5,599	1,568	932	534	478	381	428
1997 (est.)	9,587	5,344	1,615	857	520	472	369	408

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Appendix table 5-9.

Federal obligations for academic research, by agency: 1971-97

	All agencies	National Institutes of Health	National Science Foundation	Department of Defense	National Aeronautics & Space Administration	Department of Energy[a]	Department of Agriculture	All other agencies
	Percentages by agency							
1971	100.0	38.5	17.8	12.9	4.9	6.3	5.0	14.6
1972	100.0	41.2	21.1	10.8	2.9	4.9	5.3	13.8
1973	100.0	44.3	21.9	9.5	4.7	4.7	5.6	9.3
1974	100.0	51.3	18.8	8.5	4.3	4.4	4.8	7.8
1975	100.0	49.8	20.2	7.9	4.4	5.4	5.2	7.1
1976	100.0	50.6	19.1	8.5	4.4	5.2	5.3	7.0
1977	100.0	49.1	19.5	8.6	4.1	5.2	5.4	8.2
1978	100.0	49.1	18.2	8.3	4.0	6.0	6.2	8.2
1979	100.0	49.7	18.4	8.1	3.8	6.1	5.9	8.0
1980	100.0	49.6	18.4	8.5	3.9	6.1	5.8	7.8
1981	100.0	49.2	17.8	9.3	4.0	6.3	6.1	7.2
1982	100.0	49.3	17.6	10.2	3.9	5.8	6.3	6.9
1983	100.0	50.3	17.5	10.6	3.8	6.1	6.1	5.6
1984	100.0	51.2	17.5	10.7	3.5	6.2	5.2	5.8
1985	100.0	52.2	17.5	10.3	3.7	5.9	5.1	5.3
1986	100.0	51.9	16.9	12.0	3.8	5.7	4.6	5.1
1987	100.0	55.0	16.5	10.3	4.0	5.6	4.2	4.5
1988	100.0	54.9	16.3	10.4	4.4	5.5	4.3	4.2
1989	100.0	53.5	16.1	10.8	5.0	5.6	4.2	4.9
1990	100.0	53.4	16.2	9.8	5.2	5.9	4.3	5.2
1991	100.0	53.3	16.2	9.0	5.3	6.7	4.3	5.1
1992	100.0	49.9	17.0	10.1	5.7	6.7	4.8	5.9
1993	100.0	52.9	15.9	11.1	5.5	5.6	4.4	4.8
1994	100.0	53.4	16.3	10.8	5.4	5.1	4.2	4.8
1995	100.0	52.8	16.7	10.2	5.7	5.4	4.2	5.0
1996 (est.)	100.0	56.4	15.8	9.4	5.4	4.8	3.8	4.3
1997 (est.)	100.0	55.7	16.8	8.9	5.4	4.9	3.9	4.3

NOTES: Percentages may not total 100 because of rounding. Academic research includes basic research and applied research.

[a] Data for 1974 to 1976 are for the Energy Research and Development Administration; data for 1977 and thereafter are for the U.S. Department of Energy.

[b] See appendix table 4-1 for gross domestic product implicit price deflators used to convert current dollars to constant 1992 dollars.

SOURCES: National Science Foundation (NSF), Science Resources Studies Division, *Federal Funds for Research and Development: Fiscal Years 1995, 1996, and 1997*, Detailed Statistical Tables, Vol. 45, NSF 97-327 (Arlington, VA: 1997); and NSF, annual series.

Appendix table 5-10.

Distribution of federal agency academic research obligations, by field: FY 1995

(Percentages)

Field	National Science Foundation	National Aeronautics & Space Administration	Department of Defense	Department of Energy	Department of Health & Human Services	Department of Agriculture
TOTAL SCIENCE & ENGINEERING	100.0	100.0	100.0	100.0	100.0	100.0
Total sciences	77.5	82.3	61.4	85.4	98.6	94.7
Physical sciences	23.1	37.5	13.2	56.8	1.6	5.8
Astronomy	2.8	19.4	0.5	0.0	0.0	0.0
Chemistry	8.4	1.0	5.9	7.7	1.4	5.8
Physics	9.9	11.3	6.7	48.6	0.2	0.0
Other	2.1	5.9	0.1	0.5	0.0	0.0
Mathematics	4.5	0.2	3.8	1.6	0.4	0.1
Computer sciences	5.5	4.8	20.5	0.8	0.3	0.5
Environmental sciences	16.9	25.2	10.6	10.4	0.2	1.0
Atmospheric sciences	5.8	9.5	2.6	5.0	0.0	0.8
Earth sciences	5.9	3.2	2.8	4.3	0.0	0.2
Oceanography	2.9	2.2	4.3	0.8	0.0	0.0
Other	2.3	10.2	1.0	0.3	0.2	0.0
Life sciences	17.0	9.1	10.7	15.1	85.7	75.2
Agricultural sciences	0.0	0.2	0.0	0.0	0.0	35.9
Biology (excluding environmental)	11.9	4.0	2.5	10.1	39.9	20.4
Environmental biology	4.5	0.3	1.9	0.0	0.7	16.8
Medical sciences	0.0	1.6	3.8	4.5	43.0	2.1
Other	0.5	2.9	2.4	0.4	2.1	0.0
Psychology	0.8	0.7	2.0	0.0	4.3	0.0
Biological aspects	0.2	0.0	0.6	0.0	0.0	0.0
Social aspects	0.4	0.4	1.1	0.0	0.0	0.0
Other	0.2	0.3	0.3	0.0	4.3	0.0
Social sciences	4.0	0.1	0.0	0.0	1.5	12.1
Anthropology	0.7	0.0	0.0	0.0	0.0	0.0
Economics	0.7	0.0	0.0	0.0	0.1	10.4
Political science	0.4	0.0	0.0	0.0	0.0	0.0
Sociology	0.4	0.0	0.0	0.0	0.0	1.8
Other	1.8	0.1	0.0	0.0	1.4	0.0
Other sciences	5.8	4.7	0.8	0.8	4.5	0.0
Total engineering	22.5	17.7	38.6	14.6	1.4	5.3
Aeronautical	0.0	5.4	2.0	0.0	0.0	0.0
Astronautical	0.0	2.0	0.6	0.0	0.0	0.0
Chemical	2.4	0.5	0.5	3.6	0.0	0.0
Civil	2.1	0.2	1.0	0.8	0.0	0.0
Electrical	2.5	1.3	11.5	0.5	0.0	0.0
Mechanical	2.9	1.7	6.8	1.5	0.0	0.0
Materials	8.3	3.3	10.7	3.3	0.0	0.0
Other	4.2	3.4	5.6	4.9	1.4	5.3

NOTES: Academic research includes both basic and applied research. The six agencies shown are the only ones that report their research obligations to academia by science and engineering field; they represent approximately 96 percent of academic research obligations.

SOURCES: National Science Foundation (NSF), Science Resources Studies Division, *Federal Funds for Research and Development: Fiscal Years 1995, 1996, and 1997*, Detailed Statistical Tables, Vol. 45, NSF 97-327 (Arlington, VA: 1997); and NSF, annual series.

See figure 5-5. *Science & Engineering Indicators – 1998*

Appendix table 5-11.

Percentage of federal academic research obligations provided by major agencies, by field: FY 1995

Field	National Science Foundation	National Aeronautics & Space Administration	Department of Defense	Department of Energy	Department of Health & Human Services	Department of Agriculture
TOTAL SCIENCE & ENGINEERING	17.4	5.9	10.7	5.6	56.2	4.3
Total sciences	15.1	5.4	7.4	5.4	62.1	4.6
Physical sciences	33.5	18.5	11.7	26.5	7.7	2.1
Astronomy	28.8	68.0	3.2	0.0	0.0	0.0
Chemistry	40.0	1.6	17.4	11.9	22.3	6.9
Physics	29.0	11.2	12.0	46.0	1.8	0.0
Other	48.5	46.6	1.3	3.6	0.0	0.0
Mathematics	52.6	0.8	26.8	6.0	13.5	0.4
Computer sciences	26.2	7.7	59.7	1.2	4.6	0.5
Environmental sciences	46.5	23.5	17.9	9.2	2.2	0.7
Atmospheric sciences	46.7	26.0	12.6	13.0	0.0	1.6
Earth sciences	58.0	10.8	16.9	13.7	0.0	0.5
Oceanography	44.9	11.4	39.8	3.9	0.0	0.0
Other	31.3	47.8	8.6	1.3	11.1	0.0
Life sciences	5.2	0.9	2.0	1.5	84.7	5.7
Agricultural sciences	0.0	0.8	0.0	0.0	0.0	99.2
Biology (excluding environmental)	7.8	0.9	1.0	2.1	84.8	3.3
Environmental biology	37.2	0.9	9.7	0.0	17.5	34.6
Medical sciences	0.0	0.4	1.6	1.0	96.6	0.4
Other	5.3	9.8	14.9	1.4	68.6	0.0
Psychology	4.9	1.5	7.5	0.0	86.2	0.0
Biological aspects	32.4	0.9	66.5	0.0	0.2	0.0
Social aspects	34.5	10.9	54.4	0.0	0.1	0.0
Other	1.2	0.7	1.1	0.0	97.0	0.0
Social sciences	33.7	0.2	0.0	0.0	40.5	25.6
Anthropology	100.0	0.0	0.0	0.0	0.0	0.0
Economics	20.1	0.0	0.1	0.0	5.2	74.6
Political science	98.5	0.0	0.0	0.0	1.5	0.0
Sociology	41.3	0.0	0.2	0.0	11.7	46.7
Other	28.7	0.4	0.0	0.0	70.9	0.0
Other sciences	25.4	7.1	2.1	1.1	64.3	0.0
Total engineering	35.9	9.5	37.6	7.5	7.4	2.1
Aeronautical	0.0	60.2	39.8	0.0	0.0	0.0
Astronautical	0.0	63.8	36.2	0.0	0.0	0.0
Chemical	60.2	4.3	6.9	28.6	0.0	0.0
Civil	70.0	2.3	19.3	8.4	0.0	0.0
Electrical	24.8	4.2	69.3	1.7	0.0	0.0
Mechanical	36.0	7.1	50.9	6.0	0.0	0.0
Materials	48.9	6.5	38.3	6.2	0.0	0.0
Other	25.7	7.0	21.1	9.7	28.4	8.1

NOTES: Academic research includes both basic and applied research. The six agencies shown are the only ones that report their research obligations to academia by science and engineering field; they represent approximately 96 percent of academic research obligations.

SOURCES: National Science Foundation (NSF), Science Resources Studies Division, *Federal Funds for Research and Development: Fiscal Years 1995, 1996, and 1997*, Detailed Statistical Tables, Vol. 45, NSF 97-327 (Arlington, VA: 1997); and NSF, annual series.

See figure 5-6.

Science & Engineering Indicators – 1998

Appendix table 5-12.

Square footage of total, new construction, and repair/renovation of academic research space, by field: 1986-97

(Thousands of square feet)

Field	1986-87 actual	1988-89 actual	1990-91 actual	1992-93 actual	1994-95 actual	1996-97 actual/ planned
			Total space			
Total, all fields	NA	112,062	116,327	122,015	127,369	136,481
Physical sciences	NA	16,024	16,121	16,353	17,001	17,872
Mathematics	NA	722	790	829	937	1,005
Computer sciences	NA	1,437	1,445	1,606	1,779	2,075
Earth, atmospheric, and ocean sciences	NA	6,313	6,056	6,728	7,053	7,246
Agricultural sciences	NA	17,622	20,821	19,910	20,120	22,118
Biological sciences—universities & colleges	NA	16,072	17,569	17,072	16,982	18,662
Biological sciences—medical schools	NA	7,838	8,584	10,649	10,876	10,797
Medical sciences—universities & colleges	NA	5,320	4,959	6,234	6,070	7,402
Medical sciences—medical schools	NA	14,042	14,762	16,139	16,799	17,727
Psychology	NA	3,085	2,978	2,984	3,178	3,404
Social sciences	NA	3,337	3,338	3,253	3,403	3,977
Other sciences, not elsewhere classified	NA	4,350	1,846	2,162	2,442	2,363
Engineering	NA	15,900	17,057	18,095	20,730	21,832
			New construction			
Total, all fields	9,922	10,647	11,433	10,992	9,521	10,843
Physical sciences	799	2,000	1,609	1,257	1,551	1,153
Mathematics	9	25	46	44	8	72
Computer sciences	237	286	293	172	143	121
Earth, atmospheric, and ocean sciences	380	324	529	502	282	746
Agricultural sciences	1,513	1,146	955	1,218	808	1,051
Biological sciences—universities & colleges	1,275	1,549	1,374	1,169	1,028	1,804
Biological sciences—medical schools	433	712	1,426	1,020	579	465
Medical sciences—universities & colleges	613	306	673	669	388	926
Medical sciences—medical schools	1,335	1,948	2,288	3,154	1,694	2,049
Psychology	132	115	164	78	145	82
Social sciences	202	329	*	221	380	176
Other sciences, not elsewhere classified	603	418	380	420	340	77
Engineering	2,390	1,490	1,697	1,065	2,174	2,122
			Repaired/renovated space			
Total, all fields	13,431	11,449	8,606	9,134	13,122	13,698
Physical sciences	1,746	1,928	1,680	1,725	2,474	1,991
Mathematics	37	136	39	11	67	95
Computer sciences	193	144	164	54	124	142
Earth, atmospheric, and ocean sciences	362	930	450	418	521	570
Agricultural sciences	628	530	391	335	1,245	661
Biological sciences—universities & colleges	2,555	2,203	1,055	1,304	1,610	1,777
Biological sciences—medical schools	1,056	1,259	1,301	864	752	1,380
Medical sciences—universities & colleges	737	705	627	284	757	773
Medical sciences—medical schools	2,499	1,598	1,443	1,678	3,129	3,058
Psychology	256	88	254	141	182	272
Social sciences	181	119	*	236	296	346
Other sciences, not elsewhere classified	465	180	42	152	162	162
Engineering	2,716	1,630	1,159	1,932	1,803	2,410

NA = not available; * = data included with psychology

NOTES: Data for two years are combined—e.g., 1988-89 refers to two fiscal years. In the 1986-87 period, data were not reported for total R&D space. Square footage refers to net assignable square feet. Total space is actual space reported. New construction and repair/renovation for 1996-97 are planned rather than actual space. Details may not add to totals because of rounding.

SOURCE: National Science Foundation, Science Resources Studies Division, *Scientific and Engineering Research Facilities at Universities and Colleges: 1996*, NSF 96-326 (Arlington, VA: 1996).

See figure 5-8.

Science & Engineering Indicators – 1998

Appendix table 5-13.

Cost of academic research new construction and repair/renovation projects, by field: 1986-97

Field	Total cost in millions of constant 1995 dollars[a]						Cost per square foot in constant 1995 dollars					
	1986-87 actual	1988-89 actual	1990-91 actual	1992-93 actual	1994-95 actual	1996-97 planned	1986-87 actual	1988-89 actual	1990-91 actual	1992-93 actual	1994-95 actual	1996-97 planned
New construction												
Total, all fields	2,570	2,874	3,353	3,040	2,768	3,072	259	270	293	277	291	283
Physical sciences	228	468	484	364	426	390	285	234	301	290	275	338
Mathematics	2	10	14	11	2	25	222	400	304	250	250	347
Computer sciences	77	76	45	51	46	31	325	266	154	297	322	256
Earth, atmospheric, and ocean sciences	71	95	191	133	33	240	187	293	361	265	117	322
Agricultural sciences	188	177	197	227	150	212	124	154	206	186	186	202
Biological sciences—U&C	406	462	508	316	388	507	318	298	370	270	377	281
Biological sciences—MS	174	211	429	369	226	214	402	296	301	362	390	460
Medical sciences—U&C	254	71	170	173	122	243	414	232	253	259	314	262
Medical sciences—MS	378	684	738	907	525	672	283	351	323	288	310	328
Psychology	29	29	41	17	42	38	220	252	250	218	290	463
Social sciences	48	56	*	48	112	54	238	170	*	217	295	307
Other sciences, n.e.c.	174	82	90	111	122	16	289	196	237	264	359	208
Engineering	538	453	445	309	575	429	225	304	262	290	264	202
Repair/renovation												
Total, all fields	1,050	1,178	931	905	1,058	1,258	78	103	108	99	81	92
Physical sciences	132	192	170	145	192	241	76	100	101	84	78	121
Mathematics	5	13	6	2	6	1	135	96	154	182	90	11
Computer sciences	22	11	24	4	8	13	114	76	146	74	65	92
Earth, atmospheric, and ocean sciences	26	21	18	34	35	41	72	23	40	81	67	72
Agricultural sciences	25	27	39	15	72	48	40	51	100	45	58	73
Biological sciences—U&C	183	147	152	117	127	187	72	67	144	90	79	105
Biological sciences—MS	97	89	138	125	101	175	92	71	106	145	134	127
Medical sciences—U&C	65	28	59	30	59	65	88	40	94	106	78	84
Medical sciences—MS	218	188	187	253	226	132	87	118	130	151	72	43
Psychology	17	13	35	11	28	29	66	148	138	78	154	107
Social sciences	45	10	*	11	40	60	249	84	*	47	135	173
Other sciences, n.e.c.	38	19	6	8	12	42	82	106	143	53	74	259
Engineering	176	422	92	150	150	222	65	259	79	78	83	92

* = data included with psychology; n.e.c. = not elsewhere classified; U&C = universities and colleges; MS = medical schools

NOTES: Data for two years are combined—e.g., 1988-89 refers to two fiscal years. Square foot refers to net assignable square feet. Current dollars have been adjusted to 1995 constant dollars using the Bureau of Census's Composite Fixed-Weighted Price Index for Construction.

[a] Project cost estimates are prorated to reflect R&D component only.

SOURCE: National Science Foundation, Science Resources Studies Division, *Scientific and Engineering Research Facilities at Universities and Colleges: 1996*, NSF 96-326 (Arlington, VA: 1996).

Science & Engineering Indicators – 1998

Appendix table 5-14.

Funds for new construction and repair/renovation of S&E research space, by type of institution and funding source: 1986-95

Institution type and funding source	Millions of current dollars					Percent of funds				
	1986-87	1988-89	1990-91	1992-93	1994-95	1986-87	1988-89	1990-91	1992-93	1994-95
	New construction and repair/renovation									
Total, all institutions	2,888.5	3,474.0	3,801.3	3,646.9	3,825.6	100.0	100.0	100.0	100.0	100.0
Federal Government	172.7	413.1	525.3	515.4	317.1	6.0	11.9	13.8	14.1	8.3
State and local government	1,012.2	1,124.5	1,199.6	1,220.7	1,446.5	35.0	32.4	31.6	33.5	37.8
Private donations	588.5	511.3	453.2	373.4	470.8	20.4	14.7	11.9	10.2	12.3
Institutional funds	617.8	914.6	749.5	705.1	874.6	21.4	26.3	19.7	19.3	22.9
Tax-exempt bonds	450.7	390.1	793.9	700.5	476.6	15.6	11.2	20.9	19.2	12.5
Other debt	6.9	111.8	43.4	65.7	224.3	0.2	3.2	1.1	1.8	5.9
Other	39.3	6.0	36.3	65.9	15.8	1.4	0.2	1.0	1.8	0.4
Total, public institutions	1,790.7	2,425.5	2,469.3	2,536.8	2,368.1	100.0	100.0	100.0	100.0	100.0
Federal Government	53.5	305.7	412.7	360.1	154.3	3.0	12.6	16.7	14.2	6.5
State and local government	981.1	1,067.7	1,042.9	1,166.9	1,419.0	54.8	44.0	42.2	46.0	59.9
Private donations	274.1	214.9	182.9	177.4	139.9	15.3	8.9	7.4	7.0	5.9
Institutional funds	264.3	659.8	404.8	352.7	303.2	14.8	27.2	16.4	13.9	12.8
Tax-exempt bonds	215.0	161.1	410.7	446.4	324.4	12.0	6.6	16.6	17.6	13.7
Other debt	2.7	13.0	7.8	17.8	14.4	0.2	0.5	0.3	0.7	0.6
Other	0.4	0.6	7.5	15.2	13.0	0.0	0.0	0.3	0.6	0.5
Total, private institutions	1,097.8	1,048.5	1,332.0	1,110.1	1,457.5	100.0	100.0	100.0	100.0	100.0
Federal Government	119.2	107.4	112.6	155.3	162.8	10.9	10.2	8.5	14.0	11.2
State and local government	31.1	56.8	156.7	53.8	27.5	2.8	5.4	11.8	4.8	1.9
Private donations	314.4	296.4	270.3	196.0	330.9	28.6	28.3	20.3	17.7	22.7
Institutional funds	353.5	254.8	344.7	352.4	571.4	32.2	24.3	25.9	31.7	39.2
Tax-exempt bonds	235.7	229.0	383.2	254.1	152.2	21.5	21.8	28.8	22.9	10.4
Other debt	4.2	98.8	35.6	47.9	209.9	0.4	9.4	2.7	4.3	14.4
Other	38.9	5.4	28.8	50.7	2.8	3.5	0.5	2.2	4.6	0.2
	New construction									
Total, all institutions	2,050.6	2,464.5	2,975.6	2,811.9	2,767.5	100.0	100.0	100.0	100.0	100.0
Federal Government	145.4	352.0	476.3	459.3	206.4	7.1	14.3	16.0	16.3	7.5
State and local government	779.1	890.7	956.6	968.6	1,180.9	38.0	36.1	32.1	34.4	42.7
Private donations	487.5	459.2	352.6	301.0	360.0	23.8	18.6	11.8	10.7	13.0
Institutional funds	289.8	343.8	394.1	374.4	441.9	14.1	14.0	13.2	13.3	16.0
Tax-exempt bonds	313.1	320.2	727.5	620.1	426.1	15.3	13.0	24.4	22.1	15.4
Other debt	3.1	95.9	35.4	38.9	145.7	0.2	3.9	1.2	1.4	5.3
Other	31.9	0.8	33.1	49.7	6.5	1.6	0.0	1.1	1.8	0.2
Total, public institutions	1,354.8	1,727.0	2,020.0	2,016.4	1,872.3	100.0	100.0	100.0	100.0	100.0
Federal Government	40.3	274.3	388.1	325.8	115.4	3.0	15.9	19.2	16.2	6.2
State and local government	754.5	838.4	809.4	929.8	1,164.6	55.7	48.5	40.1	46.1	62.2
Private donations	259.1	192.9	139.1	152.5	123.9	19.1	11.2	6.9	7.6	6.6
Institutional funds	109.2	256.3	270.2	198.3	142.4	8.1	14.8	13.4	9.8	7.6
Tax-exempt bonds	189.5	154.5	398.6	390.5	306.1	14.0	8.9	19.7	19.4	16.3
Other debt	2.4	8.1	7.8	16.2	13.5	0.2	0.5	0.4	0.8	0.7
Other	0.2	0.6	6.9	3.3	6.5	0.0	0.0	0.3	0.2	0.3

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Appendix table 5-14.

Funds for new construction and repair/renovation of S&E research space, by type of institution and funding source: 1986-95

	Millions of current dollars					Percent of funds				
Institution type and funding source	1986-87	1988-89	1990-91	1992-93	1994-95	1986-87	1988-89	1990-91	1992-93	1994-95
Total, private institutions	695.8	737.5	955.6	795.5	895.2	100.0	100.0	100.0	100.0	100.0
Federal Government	105.1	77.7	88.2	133.5	91.0	15.1	10.5	9.2	16.8	10.2
State and local government	24.6	52.3	147.2	38.8	16.3	3.5	7.1	15.4	4.9	1.8
Private donations	228.4	266.3	213.5	148.5	236.1	32.8	36.1	22.3	18.7	26.4
Institutional funds	180.6	87.5	123.9	176.1	299.5	26.0	11.9	13.0	22.1	33.5
Tax-exempt bonds	123.6	165.7	328.9	229.6	120.0	17.8	22.5	34.4	28.9	13.4
Other debt	0.7	87.8	27.6	22.7	132.2	0.1	11.9	2.9	2.9	14.8
Other	31.7	0.2	26.2	46.4	0.0	4.6	0.0	2.7	5.8	0.0
				Repair/renovation						
Total, all institutions	1,837.9	009.5	825.7	835.0	1,058.1	100.0	100.0	100.0	100.0	100.0
Federal Government	27.3	61.1	49.0	56.1	110.7	3.3	6.1	5.9	6.7	10.5
State and local government	233.1	233.8	243.0	252.1	265.6	27.8	23.2	29.4	30.2	25.1
Private donations	101.0	52.1	100.6	72.4	110.8	12.1	5.2	12.2	8.7	10.5
Institutional funds	328.0	570.8	355.4	330.7	432.7	39.1	56.5	43.0	39.6	40.9
Tax-exempt bonds	137.6	69.9	66.4	80.4	50.5	16.4	6.9	8.0	9.6	4.8
Other debt	3.8	15.9	8.0	26.8	78.6	0.5	1.6	1.0	3.2	7.4
Other	7.4	5.2	3.2	16.2	9.3	0.9	0.5	0.4	1.9	0.9
Total, public institutions	435.9	698.5	449.3	520.4	495.8	100.0	100.0	100.0	100.0	100.0
Federal Government	13.2	31.4	24.6	34.3	38.9	3.0	4.5	5.5	6.6	7.8
State and local government	226.6	229.3	233.5	237.1	254.4	52.0	32.8	52.0	45.6	51.3
Private donations	15.0	22.0	43.8	24.9	16.0	3.4	3.1	9.7	4.8	3.2
Institutional funds	155.1	403.5	134.6	154.4	160.8	35.6	57[illegible]	30.0	29.7	32.4
Tax-exempt bonds	25.5	6.6	12.1	55.9	18.3	5.8	0.9	2.7	10.7	3.7
Other debt	0.3	4.9	0.0	1.6	0.9	0.1	0.7	0.0	0.3	0.2
Other	0.2	0.0	0.6	11.9	6.5	0.0	0.0	0.1	2.3	1.3
Total, private institutions	402.0	311.0	376.4	314.6	562.3	100.0	100.0	100.0	100.0	100.0
Federal Government	14.1	29.7	24.4	21.8	71.8	3.5	9.5	6.5	6.9	12.8
State and local government	6.5	4.5	9.5	15.0	11.2	1.6	1.4	2.5	4.8	2.0
Private donations	86.0	30.1	56.8	47.5	94.8	21.4	9.7	15.1	15.1	16.9
Institutional funds	172.9	167.3	220.8	176.3	271.9	43.0	53.8	58.7	56.0	48.4
Tax-exempt bonds	112.1	63.3	54.3	24.5	32.2	27.9	20.4	14.4	7.8	5.7
Other debt	3.5	11.0	8.0	25.2	77.7	0.9	3.5	2.1	8.0	13.8
Other	7.2	5.2	2.6	4.3	2.8	1.8	1.7	0.7	1.4	0.5

NOTES: Data for two years are combined—e.g., 1988-89 refers to two fiscal years. Details may not add to totals because of rounding.

SOURCE: National Science Foundation, Science Resources Studies Division, *Scientific and Engineering Research Facilities at Universities and Colleges: 1996*, NSF 96-326 (Arlington, VA: 1996).

See figure 5-7.

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Science & Engineering Indicators – 1998

Appendix table 5-15.

Total stock of S&E research space, by condition and field: 1988-96

(Percentages)

Field	Suitable for use in most scientifically sophisticated research					Effective for most uses, but not most scientifically sophisticated research					Requires limited repair/renovation to be used effectively					Requires major repair/renovation to be used effectively[a]					Requires replacement[b]		
	1988	1990	1992	1994	1996	1988	1990	1992	1994	1996	1988	1990	1992	1994	1996	1988	1990	1992	1994	1996	1992	1994	1996
Physical sciences	25.7	26.3	29.9	24.8	32.2	34.5	33.5	32.5	33.8	NA	22.3	23.7	23.0	23.8	48.3	17.5	16.5	12.5	15.3	NA	2.1	2.3	18.8
Mathematics	29.5	25.9	30.6	22.6	42.9	45.3	44.6	47.1	47.0	NA	19.4	21.9	17.5	24.9	46.8	5.8	7.6	3.0	4.1	NA	1.8	1.3	9.9
Computer sciences	32.6	38.3	43.9	35.2	55.0	35.0	35.5	35.4	40.9	NA	16.2	18.0	13.7	17.9	37.1	16.2	8.1	6.0	4.7	NA	1.0	1.2	7.5
Environmental sciences	18.7	18.7	22.5	22.1	32.4	40.6	40.4	41.9	35.9	NA	26.0	26.1	23.7	22.9	48.1	14.7	14.8	9.5	13.0	NA	2.4	6.0	19.1
Agricultural sciences	21.2	20.3	16.8	18.2	30.2	32.5	33.6	34.3	32.0	NA	26.2	24.1	22.7	27.4	46.2	20.0	22.0	18.5	13.6	NA	7.7	8.8	23.5
Biological sciences— universities and colleges	23.2	27.5	25.5	22.6	37.9	36.2	34.3	32.6	31.0	NA	25.0	24.2	26.7	27.1	43.8	15.5	14.0	12.5	14.2	NA	2.8	5.0	17.8
Biological sciences— medical schools	36.2	34.3	38.6	36.9	45.1	34.0	33.5	30.2	32.2	NA	16.5	18.9	17.4	15.8	40.1	13.4	13.2	12.5	13.3	NA	1.4	1.8	14.7
Medical sciences— universities and colleges	18.1	24.0	24.4	25.7	35.2	40.1	35.1	34.4	34.4	NA	27.2	23.8	24.0	23.3	43.6	14.6	17.0	13.8	11.8	NA	3.4	4.7	20.6
Medical sciences— medical schools	25.2	28.4	29.7	33.7	44.3	35.1	34.4	33.3	29.1	NA	23.1	23.7	22.3	20.5	36.0	16.6	13.4	12.6	13.5	NA	2.0	3.3	19.7
Psychology	23.2	20.5	22.2	22.8	38.2	43.7	46.6	46.9	37.9	NA	20.8	21.4	20.9	26.1	48.7	12.3	11.6	9.0	11.1	NA	1.0	2.0	12.3
Social sciences	14.8	17.2	17.1	14.4	31.8	47.7	45.0	42.8	46.2	NA	26.7	28.1	26.7	28.2	54.2	10.8	9.8	12.2	9.0	NA	1.2	1.9	13.1
Engineering	26.1	27.9	28.4	31.4	38.2	37.6	35.6	36.1	32.3	NA	22.4	22.0	22.2	21.3	43.3	13.9	14.5	10.8	12.1	NA	2.4	2.8	17.9

NA = not available

NOTES: Percentage of total is calculated within each field according to the condition of the research space. In 1996, the survey response categories were changed to "suitable for the most scientifically competitive research"; "effective for most levels of research, but may need limited repair/renovation"; and "requires major renovation or replacement to be used effectively."

[a] The data for 1988 and 1990 in this category include space requiring replacement.

[b] This category was first used in the 1992 survey.

SOURCE: National Science Foundation, Science Resources Studies Division, *Scientific and Engineering Research Facilities at Universities and Colleges 1996*, NSF 96-326 (Arlington, VA: 1996).

See text table 5-2.

Science & Engineering Indicators – 1998

Appendix table 5-16.

Adequacy of the amount of S&E research space, by field: 1988-96

	Total number of institutions					Percentage of institutions reporting that their space is:														
						Adequate					Generally adequate					Inadequate				
Field	1988	1990	1992	1994	1996	1988	1990	1992	1994	1996	1988	1990	1992	1994	1996	1988	1990	1992	1994	1996
Physical sciences	445	450	433	489	490	4.7	8.7	10.6	6.4	44.9	52.4	50.8	52.3	53.1	NA	42.9	40.5	37.0	40.5	54.5
Mathematical sciences	318	296	300	348	343	21.0	17.6	16.1	16.0	68.4	53.6	47.2	58.6	55.5	NA	25.4	35.2	25.3	28.3	30.3
Computer sciences	331	280	297	347	340	15.1	13.5	12.9	15.5	54.6	38.2	41.5	56.7	48.3	NA	46.9	45.0	30.3	36.0	43.7
Environmental sciences	297	284	314	310	306	11.0	11.1	10.5	7.2	53.7	49.4	48.4	59.4	59.6	NA	39.5	40.5	30.1	33.2	46.0
Agricultural sciences	96	94	96	123	112	11.0	17.0	17.5	10.5	48.1	51.2	39.9	48.2	59.7	NA	37.7	43.1	34.3	29.6	51.9
Biological sciences—universities and colleges	444	451	434	490	504	8.3	8.7	10.8	6.2	45.9	45.8	48.2	51.8	53.7	NA	45.9	43.1	37.4	40.1	53.3
Biological sciences—medical schools	91	105	125	132	116	3.7	10.4	3.6	10.6	55.9	47.3	35.5	60.5	53.5	NA	49.0	54.1	35.9	35.5	45.5
Medical sciences—universities and colleges	191	189	210	243	239	14.3	13.0	14.2	11.7	42.6	46.0	40.3	50.1	50.3	NA	39.7	46.7	35.7	38.2	57.4
Medical sciences—medical schools	134	141	146	126	118	0.8	7.0	4.2	10.8	34.1	52.6	33.8	54.1	44.8	NA	46.6	59.2	41.8	44.0	65.9
Psychology	403	398	388	425	430	16.8	13.2	17.2	14.8	55.4	51.4	54.3	50.0	53.9	NA	31.8	32.4	32.9	31.2	43.8
Social sciences	360	345	328	378	378	12.9	12.7	8.2	7.2	51.2	50.2	51.0	64.4	63.4	NA	36.9	36.2	27.4	29.3	47.6
Other sciences	90	69	71	63	81	10.4	16.9	14.0	15.0	51.8	51.3	39.2	44.9	50.0	NA	38.4	44.0	41.1	36.5	40.7
Engineering	283	296	290	297	288	8.7	10.6	5.8	6.7	42.8	40.1	40.8	49.1	53.3	NA	51.1	48.6	45.1	40.5	57.2

NA = not available

NOTE: The 1996 survey question included only three categories: adequate; inadequate, including insufficient; or not applicable or not needed. In previous years, the survey included five categories: adequate, generally adequate, inadequate, nonexistent but needed, or not applicable or not needed.

SOURCE: National Science Foundation, Science Resources Studies Division, *Scientific and Engineering Research Facilities at Universities and Colleges: 1996*, NSF 96-326 (Arlington, VA: 1996).

Science & Engineering Indicators – 1998

Appendix table 5-17.

Expenditures for deferred S&E research facility construction and repair/renovation needs, by field: 1996

(Millions of current dollars)

Field	Total, all needs			In a plan[a]		Not in a plan[a]	
	Construction & repair/renovation	Construction	Repair/ renovation	Construction	Repair/ renovation	Construction	Repair/ renovation
Total science & engineering	9,341	5,675	3,666	4,629	2,790	1,046	876
Physical sciences	1,857	1,175	682	1,065	587	110	95
Mathematics	123	59	64	56	53	3	11
Computer sciences	153	120	33	86	22	33	11
Environmental sciences	667	473	193	377	166	96	28
Agricultural sciences	808	516	292	356	145	160	148
Biological sciences—universities & colleges	1,445	790	656	639	508	151	148
Biological sciences—medical schools	374	200	174	166	102	34	72
Medical sciences—universities & colleges	518	328	190	238	114	90	76
Medical sciences—medical schools	1,261	767	494	660	404	107	90
Psychology	135	84	51	55	41	29	10
Social sciences	306	185	121	142	64	43	57
Other sciences	168	71	97	60	57	11	40
Engineering	1,523	907	616	727	525	180	91

[a] This refers to whether the deferred need is included (or not included) in a formal institutional plan.

SOURCE: National Science Foundation, Science Resources Studies Division, *Scientific and Engineering Research Facilities at Universities and Colleges: 1996*, NSF 96-326 (Arlington, VA: 1996).

Science & Engineering Indicators – 1998

Appendix table 5-18.
Current fund expenditures for research equipment at academic institutions, by field: 1985-95

Field	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
	Millions of current dollars										
Total expenditures											
Total science & engineering	671.6	782.9	837.0	912.0	986.1	1,012.2	1,023.9	1,032.2	1,038.5	1,100.7	1,235.3
Physical sciences	141.8	162.9	166.2	181.4	180.8	191.1	189.4	198.1	207.0	206.5	237.8
Mathematics	6.0	6.8	9.8	9.7	10.3	10.2	10.6	10.3	15.1	14.8	15.3
Computer sciences	35.5	42.6	42.8	42.7	43.0	48.0	58.5	45.0	53.4	58.7	77.0
Environmental sciences	47.8	51.3	55.4	55.8	67.5	72.1	70.0	77.5	76.4	82.9	81.2
Life sciences	282.6	330.6	335.3	379.4	431.0	419.9	411.3	429.0	416.7	435.5	464.1
Psychology	8.7	8.7	10.6	9.6	10.6	10.7	11.1	11.1	15.4	12.6	12.1
Social sciences	10.1	14.1	11.8	11.9	14.5	15.0	14.0	17.9	18.9	21.2	26.4
Other sciences	14.7	20.1	26.8	25.9	26.5	25.1	25.2	18.5	18.1	22.0	31.2
Engineering	124.4	145.9	178.3	195.5	201.9	220.0	233.8	224.7	217.4	246.5	290.2
Federal expenditures											
Total science & engineering	432.3	501.3	526.4	576.5	595.4	606.0	610.3	617.2	635.9	664.5	723.5
Physical sciences	113.2	130.5	130.5	142.8	133.2	144.0	139.3	151.5	153.6	151.0	175.8
Mathematics	4.9	5.2	7.6	7.6	6.9	6.7	6.7	7.0	11.3	10.6	9.0
Computer sciences	29.4	35.1	33.9	34.7	30.9	31.6	43.6	29.6	37.4	40.3	47.8
Environmental sciences	32.3	35.0	35.9	36.7	44.6	47.5	42.9	52.0	53.9	59.9	55.5
Life sciences	157.1	188.4	187.8	215.0	237.8	223.3	220.5	230.5	226.2	227.3	225.7
Psychology	6.2	5.9	8.1	6.5	6.9	6.8	7.1	7.1	10.6	7.7	7.7
Social sciences	4.0	4.3	3.5	3.3	4.9	4.9	5.1	7.7	7.6	8.7	10.5
Other sciences	6.8	11.7	13.7	12.1	13.2	11.5	9.6	5.2	7.5	9.6	9.8
Engineering	78.3	85.2	105.3	117.8	117.0	129.6	135.4	126.6	127.8	149.4	181.7
Nonfederal expenditures											
Total science & engineering	239.3	281.6	310.6	335.5	390.7	406.2	413.6	415.0	402.6	436.2	511.8
Physical sciences	28.6	32.4	35.7	38.7	47.6	47.1	50.1	46.6	53.4	55.5	62.0
Mathematics	1.1	1.6	2.2	2.1	3.3	3.5	3.9	3.3	3.8	4.1	6.3
Computer sciences	6.0	7.5	8.9	8.0	12.1	16.4	14.8	15.4	16.1	18.4	29.2
Environmental sciences	15.5	16.3	19.4	19.1	22.9	24.7	27.1	25.6	22.5	23.0	25.7
Life sciences	125.5	142.2	147.5	164.4	193.2	196.6	190.9	198.6	190.5	208.2	238.5
Psychology	2.5	2.8	2.5	3.0	3.7	3.9	4.0	4.1	4.8	5.0	4.4
Social sciences	6.0	9.8	8.3	8.6	9.6	10.1	8.9	10.1	11.3	12.5	15.9
Other sciences	7.9	8.3	13.1	13.9	13.3	13.5	15.6	13.2	10.6	12.5	21.4
Engineering	46.1	60.7	73.0	77.7	84.9	90.3	98.4	98.1	89.6	97.1	108.4

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Appendix table 5-18.
Current fund expenditures for research equipment at academic institutions, by field: 1985-95

Field	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
	Millions of constant 1992 dollars[a]										
Total expenditures											
Total science & engineering	856.6	971.2	1,009.2	1,062.7	1,102.6	1,086.2	1,053.9	1,032.2	1,011.7	1,047.9	1,148.1
Physical sciences	180.9	202.1	200.4	211.4	202.2	205.1	195.0	198.1	201.7	196.6	221.0
Mathematics	7.7	8.5	11.8	11.3	11.5	11.0	10.9	10.3	14.7	14.1	14.3
Computer sciences	45.2	52.8	51.6	49.8	48.1	51.5	60.2	45.0	52.1	55.9	71.6
Environmental sciences	61.0	63.6	66.7	65.0	75.4	77.4	72.0	77.5	74.4	79.0	75.5
Life sciences	360.4	410.1	404.3	442.2	481.9	450.6	423.3	429.0	406.0	414.6	431.3
Psychology	11.1	10.7	12.7	11.2	11.9	11.5	11.4	11.1	15.0	12.0	11.2
Social sciences	12.9	17.5	14.2	13.8	16.2	16.1	14.4	17.9	18.4	20.2	24.6
Other sciences	18.8	24.9	32.4	30.2	29.6	26.9	25.9	18.5	17.7	21.0	29.0
Engineering	158.7	181.0	215.0	227.8	225.8	236.1	240.6	224.7	211.8	234.7	269.7
Federal expenditures											
Total science & engineering	551.4	621.9	634.7	671.8	665.7	650.4	628.2	617.2	619.5	632.7	672.4
Physical sciences	144.4	161.9	157.4	166.4	148.9	154.5	143.4	151.5	149.6	143.8	163.4
Mathematics	6.3	6.4	9.2	8.8	7.8	7.2	6.9	7.0	11.1	10.1	8.4
Computer sciences	37.5	43.6	40.9	40.5	34.6	33.9	44.9	29.6	36.4	38.4	44.4
Environmental sciences	41.2	43.4	43.3	42.7	49.9	51.0	44.2	52.0	52.5	57.0	51.6
Life sciences	200.4	233.8	226.5	250.6	265.9	239.7	226.9	230.5	220.4	216.4	209.7
Psychology	7.9	7.3	9.8	7.6	7.8	7.3	7.3	7.1	10.3	7.3	7.2
Social sciences	5.1	5.3	4.2	3.9	5.4	5.2	5.3	7.7	7.4	8.3	9.8
Other sciences	8.7	14.5	16.5	14.1	14.7	12.4	9.9	5.2	7.3	9.1	9.1
Engineering	99.9	105.7	127.0	137.3	130.8	139.1	139.4	126.6	124.5	142.2	168.9
Nonfederal expenditures											
Total science & engineering	305.2	349.3	374.5	391.0	436.9	435.9	425.7	415.0	392.2	415.3	475.6
Physical sciences	36.5	40.2	43.0	45.1	53.2	50.6	51.6	46.6	52.1	52.8	57.6
Mathematics	1.4	2.0	2.6	2.5	3.7	3.7	4.1	3.3	3.7	3.9	5.9
Computer sciences	7.7	9.3	10.7	9.3	13.5	17.6	15.3	15.4	15.7	17.5	27.2
Environmental sciences	19.7	20.2	23.4	22.3	25.6	26.5	27.9	25.6	21.9	21.9	23.9
Life sciences	160.1	176.3	177.9	191.6	216.0	211.0	196.4	198.6	185.6	198.2	221.6
Psychology	3.2	3.5	3.0	3.5	4.1	4.2	4.1	4.1	4.7	4.7	4.1
Social sciences	7.7	12.2	10.1	10.0	10.8	10.9	9.1	10.1	11.0	11.9	14.8
Other sciences	10.1	10.4	15.8	16.2	14.9	14.5	16.0	13.2	10.4	11.9	19.9
Engineering	58.8	75.3	88.0	90.5	95.0	96.9	101.2	98.1	87.3	92.5	100.8

[a] See appendix table 4-1 for gross domestic product implicit price deflators used to convert current dollars into constant 1992 dollars.

SOURCES: National Science Foundation (NSF), Science Resources Studies Division, *Academic Science and Engineering R&D Expenditures: Fiscal Year 1995*, Detailed Statistical Tables, forthcoming (Arlington, VA: 1998); and NSF, annual series.

See figure 5-9.

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Appendix table 5-19.

Current fund expenditures for research equipment at academic institutions as a percentage of total academic R&D expenditures, by field: 1985-95

(Percentages)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Total science & engineering	6.9	7.2	6.9	6.8	6.6	6.2	5.8	5.5	5.2	5.2	5.6
Physical sciences	12.4	12.7	11.9	11.7	11.0	10.6	9.8	9.6	9.7	9.5	10.6
Mathematics	4.7	4.5	5.5	4.9	4.8	4.6	4.6	4.1	5.6	5.2	5.4
Computer sciences	12.6	13.3	11.5	10.5	9.1	9.3	10.5	8.1	8.8	9.0	11.3
Environmental sciences	6.8	6.6	6.6	6.2	6.7	6.8	6.3	6.3	5.8	5.9	5.7
Life sciences	5.4	5.6	5.1	5.2	5.3	4.8	4.3	4.2	3.8	3.8	3.8
Psychology	5.5	5.1	5.6	4.5	4.6	4.2	3.9	3.4	4.4	3.5	3.3
Social sciences	2.6	3.0	2.4	2.1	2.3	2.1	1.9	2.2	2.1	2.2	2.6
Other sciences	7.9	8.8	10.5	9.0	8.3	7.5	7.6	5.9	4.9	5.8	7.9
Engineering	8.8	8.9	9.4	9.3	8.4	8.3	8.0	7.3	6.9	7.4	8.2

SOURCES: National Science Foundation (NSF), Science Resources Studies Division, *Academic Science and Engineering R&D Expenditures: Fiscal Year 1995*, Detailed Statistical Tables, forthcoming (Arlington, VA: 1998); and NSF, annual series.

Science & Engineering Indicators – 1998

Appendix table 5-20.
Number and percentage of academic research instruments, by field, price range, and type: 1993

Field	All instruments		Computers and data handling instruments		Chromatographs and spectrometers		Microscopy instruments		Bioanalytical instruments		Other instruments	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
						All systems						
Total	61,684	100	12,023	100	13,789	100	5,597	100	10,205	100	20,071	100
Engineering	18,051	29	4,137	34	2,723	20	801	14	273	3	10,117	50
Chemistry	6,787	11	817	7	4,003	29	180	3	32	*	1,755	9
Physics/astronomy	6,415	10	1,443	12	1,159	8	212	4	303	3	3,299	16
Environmental sciences	5,126	8	1,455	12	1,740	13	554	10	142	1	1,234	6
Computer sciences	2,110	3	1,812	15	0	0	0	0	0	0	298	1
Academic departments	1,426	2	1,174	10	0	0	0	0	0	0	252	1
Computer facilities	684	1	638	5	0	0	0	0	0	0	46	*
Agricultural sciences	615	1	67	1	227	2	27	*	172	2	122	1
Biological sciences	20,978	34	2,126	18	3,797	28	3,611	65	9,217	90	2,227	11
Other, multidisciplinary	1,603	3	167	1	140	1	211	4	66	1	1,019	5
						Systems costing $20,000 - $999,999						
Total	61,348	100	11,892	100	13,730	100	5,579	100	10,205	100	19,943	100
Engineering	17,996	29	4,135	35	2,696	20	800	14	273	3	10,091	51
Chemistry	6,771	11	815	7	3,999	29	180	3	32	*	1,744	9
Physics/astronomy	6,316	10	1,443	12	1,152	8	195	3	303	3	3,224	16
Environmental sciences	5,101	8	1,449	12	1,737	13	554	10	142	1	1,218	6
Computer sciences	1,992	3	1,694	14	0	0	0	0	0	0	298	1
Academic departments	1,425	2	1,173	10	0	0	0	0	0	0	252	1
Computer facilities	567	1	521	4	0	0	0	0	0	0	46	*
Agricultural sciences	615	1	67	1	227	2	27	*	172	2	122	1
Biological sciences	20,955	34	2,122	18	3,778	28	3,611	65	9,217	90	2,227	11
Other, multidisciplinary	1,603	3	167	1	140	1	211	4	66	1	1,019	5
						Systems costing $1 million or more						
Total	337	100	131	100	59	100	19	100	0	0	128	100
Engineering	55	16	2	2	26	44	1	7	0	0	26	20
Chemistry	16	5	1	1	4	6	0	0	0	0	11	8
Physics/astronomy	99	29	0	0	7	11	17	93	0	0	75	59
Environmental sciences	25	7	5	4	3	6	0	0	0	0	16	13
Computer sciences	118	35	118	90	0	0	0	0	0	0	0	0
Academic departments	1	*	1	1	0	0	0	0	0	0	0	0
Computer facilities	117	35	117	89	0	0	0	0	0	0	0	0
Agricultural sciences	0	0	0	0	0	0	0	0	0	0	0	0
Biological sciences	23	7	3	3	19	33	0	0	0	0	0	0
Other, multidisciplinary	0	0	0	0	0	0	0	0	0	0	0	0

* = less than 0.5 percent

NOTES: Table includes data for supersystems—large, integrated instrumentation systems/facilities generally costing $1 million or more. Percentages may not total 100 because of rounding.

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Academic Research Instruments and Instrumentation Needs: 1993, available from <<http://www.nsf.gov/sbe/srs/instmnt/start.htm>>.

Appendix table 5-21.

Aggregate purchase price and percentage distribution of academic research instruments, by field, price range, and type: 1993

Field	All instruments		Computers and data handling instruments		Chromatographs and spectrometers		Microscopy instruments		Bioanalytical instruments		Other instruments	
	$ million	Percent	$ million	Percent	$ million	Percent	$ million	Percent	$ million	Percent	$ million	Percent
All systems												
Total	6,255	100	1,851	30	1,286	21	547	9	468	7	2,103	34
Engineering	1,399	100	222	16	197	14	101	7	20	1	860	61
Chemistry	678	100	68	10	472	70	9	1	2	*	127	19
Physics/astronomy	1,062	100	136	13	175	16	38	4	20	2	694	65
Environmental sciences	696	100	180	26	171	25	115	17	5	1	224	32
Computer sciences	1,135	100	1,108	98	0	0	0	0	0	0	28	2
Academic departments	103	100	88	85	0	0	0	0	0	0	15	15
Computer facilities	1,032	100	1,020	99	0	0	0	0	0	0	12	1
Agricultural sciences	25	100	3	12	11	42	2	7	5	20	5	18
Biological sciences	1,150	100	119	10	250	22	259	23	414	36	109	9
Other, multidisciplinary	108	100	16	14	11	10	23	21	2	2	57	52
Systems costing $20,000 - $999,999												
Total	4,366	100	784	18	1,124	26	527	12	468	11	1,463	34
Engineering	1,303	100	219	17	166	13	100	8	20	2	799	61
Chemistry	651	100	57	9	467	72	9	1	2	*	116	18
Physics/astronomy	501	100	136	27	84	17	19	4	20	4	243	48
Environmental sciences	502	100	111	22	164	33	115	23	5	1	107	21
Computer sciences	157	100	129	82	0	0	0	0	0	0	28	18
Academic departments	100	100	85	85	0	0	0	0	0	0	15	15
Computer facilities	56	100	44	78	0	0	0	0	0	0	12	22
Agricultural sciences	25	100	3	12	11	42	2	7	5	20	5	18
Biological sciences	1,118	100	113	10	223	20	259	23	414	37	109	10
Other, multidisciplinary	108	100	16	14	11	10	23	21	2	2	57	52
Systems costing $1 million or more												
Total	1,889	100	1,067	57	162	9	20	1	0	0	640	34
Engineering	97	100	3	3	31	32	1	1	0	0	61	63
Chemistry	27	S	11	S	5	S	0	0	0	0	11	S
Physics/astronomy	561	100	0	0	91	16	19	3	0	0	451	80
Environmental sciences	193	100	69	36	7	4	0	0	0	0	117	60
Computer sciences	978	100	978	100	0	0	0	0	0	0	0	0
Academic departments	2	S	2	S	0	0	0	0	0	0	0	0
Computer facilities	976	100	976	100	0	0	0	0	0	0	0	0
Agricultural sciences	0	0	0	0	0	0	0	0	0	0	0	0
Biological sciences	33	S	6	S	27	S	0	0	0	0	0	0
Other, multidisciplinary	0	0	0	0	0	0	0	0	0	0	0	0

* = less than 0.5 percent; S = fewer than 10 cases for analysis

NOTES: Table includes data for supersystems—large, integrated instrumentation systems/facilities generally costing $1 million or more. Percentages may not total 100 because of rounding.

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Academic Research Instruments and Instrumentation Needs: 1993, available from <<http://www.nsf.gov/sbe/srs/instmnt/start.htm>>.

Science & Engineering Indicators – 1998

Appendix table 5-22.
Current age of academic research instruments, by detailed type of instrument: 1993

Type of instrument	Current age (percent of total systems)						
	Total	0-2 years	2-4 years	4-6 years	6-8 years	8+ years	Mean age (in years)
Total, all instruments	100	17	23	21	16	23	5.8
Computers and data handling instruments	100	18	31	23	20	9	4.0
Computers/components costing $1 million and over	100	17	7	70	7	0	3.5
Computers/components costing $500,000 – $999,999	100	10	44	36	6	4	3.7
Computers/components costing $50,000 – $499,999	100	12	26	23	27	12	4.6
Computers/components costing $20,000 – $49,999	100	21	34	22	16	7	3.7
Chromatographs and spectrometers	100	14	21	19	15	32	6.0
Chromatographs and elemental analyzers	100	16	27	20	14	22	4.8
Electron/auger/ion scattering	100	21	10	18	17	34	6.1
UV/visible/infrared spectrophotometer	100	12	18	23	13	34	5.8
NMR/EPR spectrometer	100	9	10	21	15	45	8.4
X-ray diffraction systems	100	23	10	16	21	29	5.9
Other spectroscopy instruments	100	12	23	15	14	36	6.9
Microscopy instruments	100	18	23	18	15	27	6.8
Electron microscopes	100	6	21	21	12	41	9.4
Other microscopy instruments	100	24	23	16	16	21	5.5
Bioanalytical instruments	100	12	16	25	16	31	8.2
Cell sorters/counters, cytometers	100	23	22	18	21	16	4.6
Centrifuges and accessories	100	11	16	27	16	29	7.5
DNA/protein synthesizers/sequencers/analyzers	100	26	15	22	18	19	6.5
Growth/environmental chambers	100	11	22	29	14	24	5.9
Scintillation/gamma radiation/counters/detectors	100	7	15	22	13	43	10.9
Other instruments	100	20	23	19	16	21	5.3
Electronics instruments (cameras, etc.)	100	7	17	27	31	18	5.5
Temperature/pressure control/measurement instruments	100	22	19	21	18	20	5.0
Lasers and optical instruments	100	30	21	23	8	19	4.2
Robots, manufacturing machines	100	47	22	9	10	12	3.4
Telescopes/astronomical	100	*	58	4	1	36	6.9
Nuclear reactors/nuclear science instrument systems	100	0	7	25	36	32	10.7
Research vessels/planes/helicopters	100	0	38	24	13	25	5.8
Wind/wave/water/shock tunnels	S	0	0	S	0	S	S
Molecular/electron/ion beam systems	100	43	8	11	4	34	5.5
Major prototype systems	100	7	45	9	19	21	7.1
Other, not elsewhere classified	100	18	24	18	17	23	5.7

* = less than 0.5 percent; S = fewer than 10 cases for analysis

NOTE: Table does not include data for supersystems—large, integrated instrumentation systems/facilities generally costing $1 million or more.

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Academic Research Instruments and Instrumentation Needs: 1993, available from <<http://www.nsf.gov/sbe/srs/instmnt/start.htm>>.

Appendix table 5-23.

Academic employment of doctoral scientists and engineers, by type of position and field: 1973-95

(Thousands)

Field	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995
Total												
Total science & engineering	118.0	134.1	145.5	155.4	167.1	176.2	190.3	196.0	206.7	210.6	213.8	217.5
Total sciences	105.6	120.7	130.7	139.5	151.0	158.1	170.4	174.8	183.9	187.8	190.6	193.7
Physical sciences	22.1	23.6	25.0	24.6	25.4	25.1	27.0	27.2	27.7	27.7	28.6	29.3
Mathematics	9.7	11.0	11.7	12.2	12.4	12.9	13.6	13.8	14.5	15.2	15.5	14.6
Computer sciences	NA	NA	NA	0.1	0.3	0.5	0.8	1.1	1.5	2.0	2.5	3.1
Environmental sciences	3.4	3.9	4.2	4.2	4.6	4.8	5.2	5.6	5.9	6.0	6.4	6.4
Life sciences	34.9	39.4	42.6	47.0	51.3	54.9	58.7	61.3	64.8	66.9	68.2	71.6
Psychology	12.2	14.8	16.2	17.7	20.1	21.0	23.1	23.7	25.0	25.2	25.0	26.1
Social sciences	23.4	28.0	31.1	33.6	36.9	38.9	42.0	42.2	44.5	44.8	44.4	42.5
Engineering	12.4	13.4	14.8	15.8	16.1	18.1	19.9	21.2	22.9	22.8	23.1	23.8
Total full-time faculty												
Total science & engineering	103.3	116.4	125.6	131.2	142.0	148.4	156.9	164.5	169.8	173.1	172.4	171.4
Total sciences	92.0	104.2	112.2	116.9	127.3	132.0	139.0	145.2	149.6	153.1	152.3	151.3
Physical sciences	17.8	18.9	20.0	20.0	20.5	20.2	21.2	22.0	21.5	21.7	21.3	20.9
Mathematics	9.3	10.4	10.9	11.4	11.7	12.3	12.7	12.9	13.5	14.2	14.7	13.0
Computer sciences	NA	NA	NA	0.1	0.3	0.4	0.7	0.9	1.3	1.8	2.3	2.8
Environmental sciences	3.0	3.4	3.6	3.5	3.8	4.0	4.2	4.4	4.7	4.5	4.5	4.7
Life sciences	29.5	33.1	34.9	37.3	40.9	43.5	45.6	48.1	49.3	51.1	50.8	52.8
Psychology	10.8	12.8	13.9	14.3	16.4	17.3	18.5	19.2	20.2	20.7	19.5	20.1
Social sciences	21.6	25.5	28.8	30.4	33.7	34.4	36.1	37.7	39.0	39.0	39.2	37.1
Engineering	11.3	12.2	13.5	14.3	14.7	16.4	17.9	19.3	20.2	20.1	20.1	20.0
Full-time senior faculty												
Total science & engineering	74.0	84.3	90.7	97.2	107.4	115.6	119.8	127.3	131.1	133.0	128.6	127.3
Total sciences	65.3	74.5	80.0	85.6	95.0	101.9	105.9	112.0	115.2	117.2	113.0	112.1
Physical sciences	13.0	14.6	15.3	16.0	16.9	17.1	17.7	18.3	17.8	17.6	16.9	16.4
Mathematics	5.9	6.9	7.6	8.3	9.1	9.7	10.0	10.5	10.9	11.8	11.5	10.6
Computer sciences	NA	NA	NA	0.0	0.0	0.1	0.1	0.3	0.4	0.9	0.9	1.7
Environmental sciences	2.2	2.5	2.7	2.8	2.9	3.1	3.1	3.2	3.6	3.6	3.7	3.6
Life sciences	21.0	23.4	24.6	27.0	29.6	32.6	33.7	35.8	36.4	37.4	35.8	37.2
Psychology	7.3	8.7	9.1	9.9	11.7	12.8	13.5	14.3	15.0	15.3	14.3	14.5
Social sciences	15.9	18.5	20.7	21.7	24.9	26.4	27.7	29.5	31.1	30.6	29.9	28.1
Engineering	8.7	9.7	10.7	11.6	12.4	13.7	13.9	15.3	15.9	15.8	15.7	15.3

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Appendix table 5-23.
Academic employment of doctoral scientists and engineers, by type of position and field: 1973-95
(Thousands)

Field	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995
Full-time junior faculty												
Total science & engineering	29.3	32.1	34.9	34.0	34.6	32.8	37.2	37.2	38.7	40.1	43.8	44.0
Total sciences	26.7	29.6	32.2	31.3	32.3	30.2	33.1	33.2	34.4	35.8	39.3	39.3
Physical sciences	4.8	4.3	4.8	4.0	3.7	3.1	3.5	3.6	3.7	4.1	4.3	4.5
Mathematics	3.3	3.5	3.3	3.1	2.6	2.5	2.7	2.4	2.6	2.4	3.2	2.4
Computer sciences	NA	NA	NA	0.1	0.2	0.3	0.6	0.6	0.9	1.0	1.4	1.2
Environmental sciences	0.8	0.9	0.9	0.7	0.9	0.9	1.1	1.1	1.1	0.9	0.9	1.1
Life sciences	8.5	9.7	10.3	10.3	11.3	10.8	11.9	12.3	12.8	13.7	15.0	15.6
Psychology	3.6	4.2	4.8	4.4	4.8	4.5	5.0	4.9	5.2	5.4	5.2	5.5
Social sciences	5.7	7.1	8.2	8.6	8.8	8.1	8.4	8.2	7.9	8.4	9.3	9.0
Engineering	2.6	2.5	2.7	2.8	2.3	2.7	4.0	4.0	4.3	4.3	4.5	4.8
All other full-time positions												
Total science & engineering	7.6	8.3	8.8	11.4	12.6	13.4	18.1	16.4	19.2	20.2	22.2	23.9
Total sciences	6.8	7.4	8.0	10.5	11.5	12.3	16.6	15.3	17.7	18.4	20.7	21.7
Physical sciences	1.9	1.9	2.1	2.0	2.4	2.5	3.0	2.6	3.3	3.2	3.7	3.8
Mathematics	0.2	0.3	0.4	0.4	0.4	0.3	0.5	0.4	0.5	0.6	0.5	0.6
Computer sciences	NA	NA	NA	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2
Environmental sciences	0.3	0.3	0.3	0.5	0.5	0.5	0.7	0.8	0.7	0.9	1.1	1.1
Life sciences	2.5	2.4	2.8	3.9	4.0	4.6	6.2	6.0	6.7	7.2	7.7	8.4
Psychology	0.8	1.0	1.2	1.8	2.2	2.2	2.9	2.8	2.9	2.8	3.9	3.9
Social sciences	1.0	1.5	1.2	1.9	2.0	2.2	3.2	2.6	3.5	3.5	3.7	3.6
Engineering	0.8	0.9	0.8	0.9	1.1	1.1	1.5	1.1	1.5	1.8	1.5	2.1
Postdoctoral and part-time positions												
Total science & engineering	7.1	9.5	11.0	12.7	12.6	14.4	15.3	15.1	17.8	17.2	19.2	22.3
Total sciences	6.8	9.1	10.5	12.1	12.2	13.7	14.8	14.3	16.6	16.3	17.7	20.7
Physical sciences	2.3	2.7	2.8	2.7	2.5	2.4	2.8	2.6	2.9	2.8	3.7	4.7
Mathematics	0.2	0.3	0.3	0.4	0.3	0.4	0.3	0.4	0.5	0.4	0.3	1.0
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Environmental sciences	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.5	0.6	0.8	0.7
Life sciences	2.8	4.0	5.0	5.8	6.4	6.8	6.9	7.2	8.8	8.6	9.7	10.4
Psychology	0.6	0.9	1.1	1.6	1.4	1.6	1.8	1.7	1.9	1.6	1.6	2.2
Social sciences	0.8	1.0	1.1	1.3	1.3	2.2	2.6	1.9	2.1	2.3	1.5	1.8
Engineering	0.3	0.4	0.5	0.6	0.3	0.7	0.5	0.8	1.1	0.9	1.5	1.6

NA = not available

NOTES: Details may not add to totals because of rounding. Data exclude university-managed federally funded research and development centers. Due to survey coverage, the data also exclude scientists and engineers with doctorates from foreign institutions. Field of employment data were discontinued after the 1991 survey and are not shown. Faculty is defined by position. Senior faculty includes full and associate professors; junior faculty members are either assistant professors or instructors.

SOURCE: National Science Foundation, Science Resources Studies Division, *Characteristics of Doctoral Scientists and Engineers in the United States: 1995*, Detailed Statistical Tables, NSF 97-333 (Arlington, VA: 1997).

See figure 5-10.

Appendix table 5-24.

Academic employment of doctoral scientists and engineers, by degree field, sex, and type of position: 1973-95

(Thousands)

Field and sex	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995
						Total academic employment						
All, total S&E	118.0	134.1	145.5	155.4	167.1	176.2	190.3	196.0	206.7	210.6	213.8	217.5
Total sciences	105.6	120.7	130.7	139.5	151.0	158.1	170.4	174.8	183.9	187.8	190.6	193.7
Physical sciences	22.1	23.6	25.0	24.6	25.4	25.1	27.0	27.2	27.7	27.7	28.6	29.3
Mathematics	9.7	11.0	11.7	12.2	12.4	12.9	13.6	13.8	14.5	15.2	15.5	14.6
Computer sciences	NA	NA	NA	0.1	0.3	0.5	0.8	1.1	1.5	2.0	2.5	3.1
Environmental sciences	3.4	3.9	4.2	4.2	4.6	4.8	5.2	5.6	5.9	6.0	6.4	6.4
Life sciences	34.9	39.4	42.6	47.0	51.3	54.9	58.7	61.3	64.8	66.9	68.2	71.6
Psychology	12.2	14.8	16.2	17.7	20.1	21.0	23.1	23.7	25.0	25.2	25.0	26.1
Social sciences	23.4	28.0	31.1	33.6	36.9	38.9	42.0	42.2	44.5	44.8	44.4	42.5
Engineering	12.4	13.4	14.8	15.8	16.1	18.1	19.9	21.2	22.9	22.8	23.1	23.8
Male, total S&E	107.3	120.3	129.0	136.0	144.0	149.8	159.2	162.0	168.0	168.7	166.9	165.1
Total sciences	94.9	106.9	114.3	120.3	128.1	132.0	139.7	141.4	145.8	146.9	144.8	142.9
Physical sciences	20.7	22.1	23.3	22.9	23.5	23.2	24.9	24.9	25.2	25.4	25.7	25.9
Mathematics	9.0	10.3	10.8	11.3	11.3	11.8	12.3	12.5	13.0	13.9	13.7	12.8
Computer sciences	0.0	0.0	0.0	0.1	0.3	0.4	0.7	0.9	1.3	1.6	2.1	2.5
Environmental sciences	3.3	3.8	4.1	4.0	4.3	4.5	4.9	5.1	5.3	5.4	5.7	5.5
Life sciences	30.8	34.3	36.6	40.1	42.9	44.5	46.7	47.9	49.5	50.1	49.4	50.1
Psychology	10.0	11.8	12.6	13.5	14.9	15.1	16.0	16.2	16.5	16.0	14.7	14.7
Social sciences	21.0	24.7	26.9	28.5	30.9	32.3	34.3	33.9	35.1	34.6	33.4	31.3
Engineering	12.3	13.3	14.7	15.7	15.9	17.8	19.5	20.6	22.2	21.8	22.1	22.3
Female, total S&E	10.7	13.8	16.5	19.4	23.1	26.5	31.1	34.0	38.7	41.9	46.9	52.4
Total sciences	10.7	13.8	16.4	19.2	22.9	26.1	30.7	33.5	38.0	40.9	45.8	50.9
Physical sciences	1.4	1.5	1.6	1.7	1.9	1.9	2.1	2.3	2.5	2.3	2.9	3.5
Mathematics	0.6	0.8	0.9	0.9	1.1	1.1	1.3	1.4	1.5	1.4	1.7	1.8
Computer sciences	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.4	0.5	0.6
Environmental sciences	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.7	0.9
Life sciences	4.0	5.1	6.0	6.9	8.4	10.3	12.1	13.3	15.3	16.8	18.8	21.5
Psychology	2.2	3.0	3.6	4.3	5.2	5.9	7.1	7.6	8.5	9.2	10.3	11.5
Social sciences	2.4	3.3	4.2	5.2	6.0	6.5	7.7	8.3	9.4	10.2	10.9	11.2
Engineering	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.6	0.7	1.0	1.1	1.5

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Appendix table 5-24.

Academic employment of doctoral scientists and engineers, by degree field, sex, and type of position: 1973-95

(Thousands)

Field and sex	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995
					Full-time senior faculty							
All, total S&E	74.0	84.3	90.7	97.2	107.4	115.6	119.8	127.3	131.1	133.0	128.6	127.3
Total sciences	65.3	74.5	80.0	85.6	95.0	101.9	105.9	112.0	115.2	117.2	113.0	112.1
Physical sciences	13.0	14.6	15.3	16.0	16.9	17.1	17.7	18.3	17.8	17.6	16.9	16.4
Mathematics	5.9	6.9	7.6	8.3	9.1	9.7	10.0	10.5	10.9	11.8	11.5	10.6
Computer sciences	NA	NA	NA	0.0	0.0	0.1	0.1	0.3	0.4	0.9	0.9	1.7
Environmental sciences	2.2	2.5	2.7	2.8	2.9	3.1	3.1	3.2	3.6	3.6	3.7	3.6
Life sciences	21.0	23.4	24.6	27.0	29.6	32.6	33.7	35.8	36.4	37.4	35.8	37.2
Psychology	7.3	8.7	9.1	9.9	11.7	12.8	13.5	14.3	15.0	15.3	14.3	14.5
Social sciences	15.9	18.5	20.7	21.7	24.9	26.4	27.7	29.5	31.1	30.6	29.9	28.1
Engineering	8.7	9.7	10.7	11.6	12.4	13.7	13.9	15.3	15.9	15.8	15.7	15.3
Male, total S&E	69.7	78.9	84.7	90.3	98.7	104.9	107.4	113.3	115.3	115.5	110.3	107.0
Total sciences	61.0	69.2	74.0	78.7	86.5	91.4	93.7	98.2	99.6	100.1	95.0	92.2
Physical sciences	12.5	14.1	14.7	15.4	16.2	16.4	17.0	17.5	16.9	16.9	16.0	15.4
Mathematics	5.6	6.5	7.2	7.9	8.6	9.1	9.3	9.8	10.0	10.8	10.5	9.8
Computer sciences	NA	NA	NA	0.0	0.0	0.1	0.1	0.3	0.4	0.8	0.8	1.4
Environmental sciences	2.2	2.5	2.7	2.7	2.8	3.0	3.0	3.1	3.4	3.4	3.5	3.4
Life sciences	19.5	21.6	22.7	24.9	26.9	29.1	29.4	31.0	31.1	31.4	29.3	29.3
Psychology	6.4	7.6	7.8	8.4	9.7	10.5	10.8	11.2	11.5	11.3	10.2	10.1
Social sciences	14.7	16.9	18.8	19.5	22.3	23.2	24.2	25.4	26.4	25.5	24.7	22.8
Engineering	8.7	9.7	10.7	11.5	12.2	13.6	13.7	15.1	15.7	15.4	15.3	14.8
Female, total S&E	4.3	5.4	6.0	7.0	8.6	10.7	12.4	14.0	15.8	17.6	18.3	20.3
Total sciences	4.3	5.4	6.0	6.9	8.5	10.5	12.2	13.8	15.6	17.1	18.0	19.8
Physical sciences	0.5	0.5	0.6	0.6	0.6	0.7	0.8	0.9	0.9	0.7	0.9	1.0
Mathematics	0.3	0.4	0.4	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.0	0.8
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.3
Environmental sciences	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
Life sciences	1.5	1.8	1.9	2.2	2.7	3.5	4.3	4.8	5.4	6.1	6.5	7.8
Psychology	0.8	1.1	1.2	1.4	2.0	2.4	2.7	3.1	3.5	4.0	4.1	4.4
Social sciences	1.1	1.5	1.8	2.2	2.6	3.1	3.6	4.1	4.7	5.1	5.2	5.3
Engineering	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.4	0.3	0.5

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Appendix table 5-24.

Academic employment of doctoral scientists and engineers, by degree field, sex, and type of position: 1973-95

(Thousands)

Field and sex	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995
						Full-time junior faculty						
All, total S&E	29.3	32.1	34.9	34.0	34.6	32.8	37.2	37.2	38.7	40.1	43.8	44.0
Total sciences	26.7	29.6	32.2	31.3	32.3	30.2	33.1	33.2	34.4	35.8	39.3	39.3
Physical sciences	4.8	4.3	4.8	4.0	3.7	3.1	3.5	3.6	3.7	4.1	4.3	4.5
Mathematics	3.3	3.5	3.3	3.1	2.6	2.5	2.7	2.4	2.6	2.4	3.2	2.4
Computer sciences	NA	NA	NA	0.1	0.2	0.3	0.6	0.6	0.9	1.0	1.4	1.2
Environmental sciences	0.8	0.9	0.9	0.7	0.9	0.9	1.1	1.1	1.1	0.9	0.9	1.1
Life sciences	8.5	9.7	10.3	10.3	11.3	10.8	11.9	12.3	12.8	13.7	15.0	15.6
Psychology	3.6	4.2	4.8	4.4	4.8	4.5	5.0	4.9	5.2	5.4	5.2	5.5
Social sciences	5.7	7.1	8.2	8.6	8.8	8.1	8.4	8.2	7.9	8.4	9.3	9.0
Engineering	2.6	2.5	2.7	2.8	2.3	2.7	4.0	4.0	4.3	4.3	4.5	4.8
Male, total S&E	26.0	27.5	28.9	27.3	27.1	25.2	27.8	27.2	27.6	28.1	29.7	28.5
Total sciences	23.5	25.1	26.3	24.6	24.9	22.6	23.9	23.4	23.5	24.2	25.7	24.4
Physical sciences	4.5	4.0	4.4	3.6	3.2	2.7	3.0	3.2	3.2	3.4	3.5	3.4
Mathematics	3.1	3.2	2.9	2.7	2.2	2.2	2.3	2.0	2.2	2.2	2.7	2.0
Computer sciences	NA	NA	NA	0.1	0.2	0.3	0.5	0.5	0.8	0.8	1.1	1.0
Environmental sciences	0.7	0.9	0.8	0.7	0.9	0.8	0.9	0.9	0.9	0.7	0.7	0.7
Life sciences	7.5	8.1	8.4	8.1	8.9	8.1	8.5	8.5	8.4	8.8	9.5	9.5
Psychology	2.7	3.0	3.3	2.8	3.0	2.6	2.7	2.7	2.9	3.0	2.3	2.4
Social sciences	5.0	5.9	6.5	6.6	6.5	5.9	6.0	5.6	5.2	5.3	5.9	5.5
Engineering	2.6	2.4	2.7	2.7	2.2	2.6	3.8	3.8	4.0	3.9	4.0	4.1
Female, total S&E	3.3	4.6	6.0	6.8	7.5	7.7	9.4	10.0	11.2	12.0	14.1	15.6
Total sciences	3.3	4.6	5.9	6.7	7.4	7.6	9.2	9.7	10.8	11.6	13.6	14.9
Physical sciences	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.7	0.9	1.1
Mathematics	0.2	0.3	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.3	0.5	0.5
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.2
Environmental sciences	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.4
Life sciences	1.1	1.6	1.9	2.2	2.4	2.7	3.4	3.8	4.5	4.9	5.5	6.1
Psychology	0.9	1.2	1.5	1.6	1.8	1.9	2.3	2.2	2.3	2.4	2.9	3.1
Social sciences	0.8	1.2	1.7	2.1	2.3	2.1	2.4	2.6	2.7	3.0	3.4	3.5
Engineering	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.7

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Appendix table 5-24.

Academic employment of doctoral scientists and engineers, by degree field, sex, and type of position: 1973-95

(Thousands)

Field and sex	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995
					All other full-time positions							
All, total S&E	7.6	8.3	8.8	11.4	12.6	13.4	18.1	16.4	19.2	20.2	22.2	23.9
Total sciences	6.8	7.4	8.0	10.5	11.5	12.3	16.6	15.3	17.7	18.4	20.7	21.7
Physical sciences	1.9	1.9	2.1	2.0	2.4	2.5	3.0	2.6	3.3	3.2	3.7	3.8
Mathematics	0.2	0.3	0.4	0.4	0.4	0.3	0.5	0.4	0.5	0.6	0.5	0.6
Computer sciences	NA	NA	NA	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2
Environmental sciences	0.3	0.3	0.3	0.5	0.5	0.5	0.7	0.8	0.7	0.9	1.1	1.1
Life sciences	2.5	2.4	2.8	3.9	4.0	4.6	6.2	6.0	6.7	7.2	7.7	8.4
Psychology	0.8	1.0	1.2	1.8	2.2	2.2	2.9	2.8	2.9	2.8	3.9	3.9
Social sciences	1.0	1.5	1.2	1.9	2.0	2.2	3.2	2.6	3.5	3.5	3.7	3.6
Engineering	0.8	0.9	0.8	0.9	1.1	1.1	1.5	1.1	1.5	1.8	1.5	2.1
Male, total S&E	6.5	7.2	7.4	9.5	10.0	10.3	14.3	12.0	13.9	14.4	15.4	16.1
Total sciences	5.7	6.4	6.7	8.6	8.9	9.3	12.8	10.9	12.5	12.8	14.0	14.1
Physical sciences	1.8	1.8	1.9	1.8	2.1	2.2	2.7	2.2	2.9	2.9	3.3	3.2
Mathematics	0.2	0.3	0.4	0.3	0.3	0.2	0.4	0.4	0.4	0.6	0.4	0.5
Computer sciences	NA	NA	NA	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Environmental sciences	0.3	0.3	0.3	0.5	0.5	0.5	0.7	0.7	0.6	0.7	0.9	0.9
Life sciences	2.0	1.9	2.2	3.0	3.0	3.2	4.6	4.1	4.6	4.9	5.1	5.6
Psychology	0.7	0.8	0.9	1.4	1.4	1.4	1.8	1.6	1.5	1.2	1.9	1.7
Social sciences	0.8	1.3	0.9	1.6	1.6	1.7	2.5	1.8	2.4	2.4	2.2	2.1
Engineering	0.8	0.9	0.8	0.9	1.1	1.0	1.5	1.0	1.4	1.7	1.5	2.0
Female, total S&E	1.1	1.1	1.4	2.0	2.6	3.1	3.8	4.5	5.3	5.8	6.7	7.7
Total sciences	1.1	1.1	1.4	2.0	2.6	3.1	3.8	4.4	5.2	5.7	6.7	7.6
Physical sciences	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.3	0.4	0.6
Mathematics	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Environmental sciences	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.2
Life sciences	0.6	0.5	0.6	0.9	1.0	1.3	1.6	1.8	2.1	2.4	2.6	2.8
Psychology	0.2	0.2	0.3	0.5	0.8	0.8	1.1	1.3	1.4	1.6	2.0	2.2
Social sciences	0.2	0.2	0.2	0.3	0.4	0.5	0.7	0.8	1.1	1.1	1.5	1.5
Engineering	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1

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Appendix table 5-24.

Academic employment of doctoral scientists and engineers, by degree field, sex, and type of position: 1973-95

(Thousands)

Field and sex	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995
Postdoctoral and part-time positions												
All, total S&E	7.1	9.5	11.0	12.7	12.6	14.4	15.3	15.1	17.8	17.2	19.2	22.3
Total sciences	6.8	9.1	10.5	12.1	12.2	13.7	14.8	14.3	16.6	16.3	17.7	20.7
Physical sciences	2.3	2.7	2.8	2.7	2.5	2.4	2.8	2.6	2.9	2.8	3.7	4.7
Mathematics	0.2	0.3	0.3	0.4	0.3	0.4	0.3	0.4	0.5	0.4	0.3	1.0
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Environmental sciences	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.5	0.6	0.8	0.7
Life sciences	2.8	4.0	5.0	5.8	6.4	6.8	6.9	7.2	8.8	8.6	9.7	10.4
Psychology	0.6	0.9	1.1	1.6	1.4	1.6	1.8	1.7	1.9	1.6	1.6	2.2
Social sciences	0.8	1.0	1.1	1.3	1.3	2.2	2.6	1.9	2.1	2.3	1.5	1.8
Engineering	0.3	0.4	0.5	0.6	0.3	0.7	0.5	0.8	1.1	0.9	1.5	1.6
Male, total S&E	5.0	6.7	7.8	9.0	8.2	9.4	9.8	9.5	11.3	10.7	11.5	13.5
Total sciences	4.7	6.3	7.3	8.4	7.8	8.7	9.3	8.8	10.2	9.8	10.1	12.1
Physical sciences	1.9	2.2	2.3	2.2	1.9	1.9	2.2	2.0	2.3	2.2	3.0	3.8
Mathematics	0.1	0.2	0.2	0.3	0.2	0.2	0.2	0.3	0.4	0.3	0.1	0.6
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Environmental sciences	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.5	0.6	0.5
Life sciences	2.0	2.7	3.3	4.1	4.1	4.1	4.2	4.3	5.5	5.1	5.6	5.7
Psychology	0.2	0.4	0.6	0.9	0.8	0.7	0.8	0.7	0.6	0.4	0.2	0.5
Social sciences	0.5	0.6	0.7	0.8	0.6	1.5	1.6	1.1	1.1	1.4	0.6	0.9
Engineering	0.3	0.3	0.5	0.6	0.3	0.6	0.5	0.7	1.1	0.9	1.3	1.4
Female, total S&E	2.1	2.8	3.2	3.7	4.4	5.0	5.6	5.6	6.4	6.6	7.7	8.8
Total sciences	2.1	2.8	3.2	3.7	4.4	5.0	5.5	5.5	6.4	6.5	7.6	8.5
Physical sciences	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.8	0.8
Mathematics	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Environmental sciences	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1
Life sciences	0.9	1.3	1.6	1.8	2.3	2.7	2.8	2.9	3.3	3.5	4.1	4.7
Psychology	0.4	0.5	0.5	0.7	0.7	0.8	1.0	1.0	1.3	1.2	1.4	1.7
Social sciences	0.3	0.4	0.4	0.5	0.7	0.7	1.0	0.8	1.0	0.9	0.9	0.9
Engineering	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.3

NA = not available

NOTES: Data exclude university-managed federally funded research and development centers. Due to survey coverage, the data also exclude scientists and engineers with doctorates from foreign institutions. Field of employment data were discontinued after the 1991 survey and are not shown. Faculty is defined by position. Senior faculty includes full and associate professors; junior faculty members are either assistant professors or instructors.

SOURCE: National Science Foundation, Science Resources Studies Division, *Characteristics of Doctoral Scientists and Engineers in the United States: 1995*, Detailed Statistical Tables, NSF 97-333 (Arlington, VA: 1997).

Appendix table 5-25.

Academic employment of doctoral scientists and engineers, by degree field, race/ethnicity, and type of position: 1973-95

(Thousands)

Field and race/ethnicity	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995
Total academic employment												
All, total S&E	118.0	134.1	145.5	155.4	167.1	176.2	190.3	196.0	206.7	210.6	213.8	217.5
Total sciences	105.6	120.7	130.7	139.5	151.0	158.1	170.4	174.8	183.9	187.8	190.6	193.7
Physical sciences	22.1	23.6	25.0	24.6	25.4	25.1	27.0	27.2	27.7	27.7	28.6	29.3
Mathematics	9.7	11.0	11.7	12.2	12.4	12.9	13.6	13.8	14.5	15.2	15.5	14.6
Computer sciences	NA	NA	NA	0.1	0.3	0.5	0.8	1.1	1.5	2.0	2.5	3.1
Environmental sciences	3.4	3.9	4.2	4.2	4.6	4.8	5.2	5.6	5.9	6.0	6.4	6.4
Life sciences	34.9	39.4	42.6	47.0	51.3	54.9	58.7	61.3	64.8	66.9	68.2	71.6
Psychology	12.2	14.8	16.2	17.7	20.1	21.0	23.1	23.7	25.0	25.2	25.0	26.1
Social sciences	23.4	28.0	31.1	33.6	36.9	38.9	42.0	42.2	44.5	44.8	44.4	42.5
Engineering	12.4	13.4	14.8	15.8	16.1	18.1	19.9	21.2	22.9	22.8	23.1	23.8
White non-Hispanic, total S&E	107.8	121.6	131.5	140.0	150.0	157.3	168.5	172.9	181.1	183.5	181.8	182.6
Total sciences	97.0	110.0	118.8	126.5	135.9	142.1	152.1	155.8	163.0	165.3	164.3	165.0
Physical sciences	19.7	21.1	22.1	21.9	22.3	21.9	23.4	23.3	23.7	23.8	23.4	23.8
Mathematics	8.8	10.0	10.6	10.8	11.0	11.5	11.9	12.2	12.6	13.0	12.9	12.0
Computer sciences	NA	NA	NA	0.1	0.2	0.4	0.6	0.9	1.1	1.4	1.6	2.1
Environmental sciences	3.3	3.7	4.0	4.0	4.3	4.5	4.9	5.2	5.5	5.7	5.9	5.7
Life sciences	32.2	35.8	38.8	42.4	46.1	49.4	52.7	54.7	57.6	59.2	59.1	61.3
Psychology	11.6	13.9	15.2	16.8	18.8	19.6	21.3	22.0	23.2	23.2	22.9	23.6
Social sciences	21.4	25.3	28.2	30.5	33.1	34.7	37.3	37.6	39.4	39.1	38.6	36.5
Engineering	10.8	11.6	12.6	13.5	14.0	15.2	16.4	17.2	18.1	18.2	17.5	17.6
Asian, total S&E	5.1	6.1	6.8	9.8	10.9	11.8	14.1	15.1	16.4	16.9	21.0	22.5
Total sciences	4.0	5.0	5.4	7.9	9.2	9.5	11.1	11.6	12.3	13.2	16.3	17.6
Physical sciences	1.1	1.3	1.4	1.9	2.0	2.2	2.6	2.9	2.8	2.6	3.8	4.1
Mathematics	0.4	0.5	0.5	0.9	0.9	1.0	1.1	1.1	1.3	1.6	1.9	1.8
Computer sciences	NA	NA	NA	0.0	0.1	0.1	0.1	0.1	0.3	0.5	0.8	0.9
Environmental sciences	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.5
Life sciences	1.3	1.8	2.0	3.1	3.6	3.6	4.0	4.5	4.8	5.1	6.4	6.8
Psychology	0.1	0.2	0.2	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6
Social sciences	1.0	1.1	1.2	1.6	2.0	2.0	2.5	2.2	2.4	2.6	2.7	2.8
Engineering	1.1	1.1	1.3	1.9	1.8	2.4	3.0	3.5	4.1	3.7	4.7	4.9
Underrep. minorities, total S&E[a]	2.4	3.2	3.8	5.0	6.0	6.8	7.3	8.0	9.2	10.2	11.5	12.8
Total sciences	2.3	3.0	3.5	4.6	5.7	6.2	6.8	7.4	8.5	9.3	10.5	11.5
Physical sciences	0.5	0.5	0.5	0.7	0.9	1.0	0.9	1.0	1.1	1.3	1.6	1.5
Mathematics	0.2	0.2	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.8	0.9
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2
Environmental sciences	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
Life sciences	0.9	1.1	1.2	1.4	1.6	1.8	1.9	2.1	2.5	2.6	2.9	3.6
Psychology	0.3	0.4	0.6	0.6	0.9	1.0	1.3	1.2	1.3	1.5	1.7	2.0
Social sciences	0.5	0.8	0.8	1.5	1.8	2.0	2.2	2.4	2.8	3.1	3.2	3.2
Engineering	0.2	0.2	0.3	0.4	0.3	0.5	0.5	0.5	0.7	0.9	1.0	1.3

Appendix table 5-25.

Academic employment of doctoral scientists and engineers, by degree field, race/ethnicity, and type of position: 1973-95

(Thousands)

Field and race/ethnicity	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995
Black, total S&E	1.3	1.7	1.8	2.0	2.6	3.3	3.4	3.6	3.8	4.7	4.9	6.1
Total sciences	1.3	1.6	1.7	1.9	2.5	3.0	3.2	3.3	3.6	4.3	4.6	5.6
Physical sciences	0.3	0.2	0.2	0.2	0.3	0.4	0.3	0.3	0.3	0.4	0.5	0.6
Mathematics	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Environmental sciences	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Life sciences	0.4	0.6	0.6	0.6	0.6	0.8	0.9	0.9	1.0	1.2	1.3	1.8
Psychology	0.2	0.3	0.3	0.3	0.4	0.6	0.6	0.7	0.7	0.9	0.9	1.1
Social sciences	0.3	0.5	0.5	0.7	1.0	1.1	1.3	1.2	1.3	1.6	1.6	1.8
Engineering	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.3	0.4	0.3	0.5
Hispanic, total S&E	0.9	1.2	1.6	2.4	2.5	2.6	3.1	3.4	4.3	4.5	5.0	5.7
Total sciences	0.8	1.1	1.4	2.1	2.4	2.4	2.8	3.1	3.9	4.1	4.4	5.0
Physical sciences	0.2	0.2	0.3	0.4	0.4	0.5	0.5	0.5	0.6	0.8	0.8	0.8
Mathematics	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.5
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1
Environmental sciences	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Life sciences	0.4	0.4	0.5	0.7	0.8	0.8	0.8	1.0	1.2	1.2	1.3	1.6
Psychology	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.8
Social sciences	0.1	0.2	0.2	0.6	0.5	0.6	0.7	0.8	1.1	1.1	1.2	1.1
Engineering	0.1	0.1	0.2	0.3	0.1	0.2	0.3	0.3	0.4	0.4	0.5	0.7
Native American, total S&E	0.2	0.3	0.4	0.6	0.8	0.8	0.8	0.9	1.1	0.9	1.0	1.0
Total sciences	0.2	0.3	0.4	0.6	0.7	0.7	0.7	0.9	1.0	0.8	1.0	0.9
Physical sciences	0.0	0.1	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.1
Mathematics	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Environmental sciences	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Life sciences	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Psychology	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.2
Social sciences	0.1	0.1	0.1	0.2	0.3	0.3	0.2	0.3	0.5	0.4	0.4	0.3
Engineering	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.1

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Appendix table 5-25.
Academic employment of doctoral scientists and engineers, by degree field, race/ethnicity, and type of position: 1973-95
(Thousands)

Field and race/ethnicity	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995
					Full-time faculty							
All, total S&E	103.3	116.4	125.6	131.2	142.0	148.4	156.9	164.5	169.8	173.1	172.4	171.4
Total sciences	92.0	104.2	112.2	116.9	127.3	132.0	139.0	145.2	149.6	153.1	152.3	151.3
Physical sciences	17.8	18.9	20.0	20.0	20.5	20.2	21.2	22.0	21.5	21.7	21.3	20.9
Mathematics	9.3	10.4	10.9	11.4	11.7	12.3	12.7	12.9	13.5	14.2	14.7	13.0
Computer sciences	NA	NA	NA	0.1	0.3	0.4	0.7	0.9	1.3	1.8	2.3	2.8
Environmental sciences	3.0	3.4	3.6	3.5	3.8	4.0	4.2	4.4	4.7	4.5	4.5	4.7
Life sciences	29.5	33.1	34.9	37.3	40.9	43.5	45.6	48.1	49.3	51.1	50.8	52.8
Psychology	10.8	12.8	13.9	14.3	16.4	17.3	18.5	19.2	20.2	20.7	19.5	20.1
Social sciences	21.6	25.5	28.8	30.4	33.7	34.4	36.1	37.7	39.0	39.0	39.2	37.1
Engineering	11.3	12.2	13.5	14.3	14.7	16.4	17.9	19.3	20.2	20.1	20.2	20.0
White non-Hispanic, total S&E	94.9	106.2	114.3	118.7	128.1	133.4	139.7	146.2	149.8	151.8	148.7	147.1
Total sciences	85.0	95.6	102.6	106.5	115.4	119.4	124.9	130.4	133.6	135.7	133.1	131.7
Physical sciences	16.1	17.2	18.0	18.0	18.5	17.8	18.8	19.3	18.9	18.9	18.0	17.8
Mathematics	8.5	9.5	9.9	10.1	10.3	10.9	11.1	11.4	11.7	12.2	12.3	10.7
Computer sciences	NA	NA	NA	0.0	0.2	0.3	0.5	0.7	1.0	1.3	1.5	1.9
Environmental sciences	2.9	3.3	3.5	3.3	3.6	3.8	4.0	4.1	4.4	4.3	4.2	4.3
Life sciences	27.5	30.4	32.1	33.9	37.2	39.7	41.3	43.4	44.4	46.0	45.1	46.7
Psychology	10.3	12.1	13.0	13.6	15.4	16.2	17.1	17.9	18.8	19.2	18.0	18.4
Social sciences	19.7	23.2	26.1	27.5	30.2	30.7	32.2	33.6	34.4	33.8	34.1	31.9
Engineering	10.0	10.6	11.6	12.2	12.7	14.0	14.8	15.9	16.2	16.2	15.6	15.3
Asian, total S&E	4.0	4.7	5.0	7.8	8.4	9.2	10.9	11.7	12.4	12.7	14.9	14.5
Total sciences	3.0	3.7	3.9	6.0	6.8	7.2	8.2	8.8	9.0	9.6	11.2	11.0
Physical sciences	0.7	0.8	0.9	1.3	1.2	1.5	1.6	1.8	1.7	1.7	2.2	2.0
Mathematics	0.4	0.5	0.5	0.8	0.9	1.0	1.1	1.1	1.3	1.5	1.7	1.6
Computer sciences	NA	NA	NA	0.0	0.0	0.1	0.1	0.1	0.3	0.5	0.7	0.8
Environmental sciences	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3
Life sciences	0.9	1.2	1.3	2.1	2.3	2.4	2.8	3.1	3.1	3.0	3.7	3.5
Psychology	0.1	0.1	0.1	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4
Social sciences	0.9	1.1	1.1	1.5	1.9	1.9	2.1	2.1	2.2	2.4	2.3	2.5
Engineering	0.9	1.0	1.1	1.8	1.7	1.9	2.7	3.0	3.4	3.1	3.7	3.6
Underrep. minorities, total S&E[a]	2.1	2.7	3.3	4.3	5.2	5.6	5.9	6.5	7.6	8.7	9.2	10.0
Total sciences	1.9	2.5	3.0	4.0	4.9	5.2	5.5	6.0	7.0	7.9	8.3	8.9
Physical sciences	0.4	0.4	0.4	0.6	0.8	0.9	0.7	0.8	0.9	1.1	1.2	1.1
Mathematics	0.2	0.2	0.2	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.7	0.7
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2
Environmental sciences	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Life sciences	0.7	0.9	1.0	1.1	1.4	1.4	1.5	1.7	1.9	2.1	2.1	2.6
Psychology	0.2	0.3	0.5	0.4	0.6	0.8	0.9	0.9	1.0	1.2	1.1	1.4
Social sciences	0.4	0.6	0.8	1.4	1.6	1.7	1.8	2.0	2.5	2.9	2.9	2.8
Engineering	0.1	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.6	0.8	0.9	1.1

Appendix table 5-25.

Academic employment of doctoral scientists and engineers, by degree field, race/ethnicity, and type of position: 1973-95

(Thousands)

Field and race/ethnicity	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995
Black, total S&E	1.2	1.4	1.5	1.7	2.3	2.6	2.7	2.9	3.2	4.1	3.9	4.8
Total sciences	1.1	1.3	1.5	1.6	2.2	2.4	2.6	2.7	3.0	3.7	3.6	4.3
Physical sciences	0.2	0.2	0.2	0.2	0.2	0.3	0.1	0.2	0.3	0.4	0.4	0.5
Mathematics	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Environmental sciences	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Life sciences	0.3	0.5	0.5	0.5	0.5	0.6	0.7	0.7	0.8	1.0	1.0	1.3
Psychology	0.1	0.2	0.3	0.2	0.4	0.4	0.5	0.5	0.6	0.7	0.6	0.6
Social sciences	0.3	0.4	0.4	0.6	0.9	0.9	1.1	1.0	1.1	1.5	1.4	1.5
Engineering	0.1	0.1	0.0	0.1	0.1	0.2	0.1	0.2	0.2	0.4	0.3	0.5
Hispanic, total S&E	0.7	1.0	1.3	2.0	2.1	2.2	2.4	2.7	3.3	3.7	3.9	4.4
Total sciences	0.6	0.9	1.2	1.7	2.0	2.0	2.2	2.5	3.0	3.3	3.5	3.8
Physical sciences	0.1	0.2	0.2	0.3	0.4	0.4	0.4	0.5	0.4	0.6	0.6	0.5
Mathematics	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1
Environmental sciences	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Life sciences	0.3	0.4	0.4	0.5	0.7	0.6	0.6	0.8	0.9	0.9	0.9	1.2
Psychology	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.5
Social sciences	0.1	0.2	0.2	0.5	0.5	0.5	0.5	0.7	0.9	1.0	1.0	1.0
Engineering	0.1	0.1	0.2	0.2	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.6
Native American, total S&E	0.2	0.3	0.4	0.6	0.7	0.8	0.8	0.9	1.0	0.8	0.9	0.8
Total sciences	0.2	0.3	0.3	0.6	0.7	0.7	0.7	0.8	0.9	0.8	0.8	0.7
Physical sciences	0.0	0.1	0.0	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Mathematics	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Environmental sciences	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Life sciences	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2
Psychology	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Social sciences	0.1	0.1	0.1	0.2	0.3	0.3	0.2	0.3	0.4	0.4	0.4	0.3
Engineering	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.1	0.1
Full-time nonfaculty, part-time, and postdoctorate positions												
All, total S&E	14.7	17.8	19.9	24.1	25.2	27.8	33.4	31.5	36.9	37.4	41.4	46.2
Total sciences	13.6	16.5	18.5	22.6	23.7	26.1	31.4	29.6	34.3	34.7	38.4	42.4
Physical sciences	4.2	4.6	4.9	4.7	4.8	5.0	5.8	5.2	6.2	6.0	7.4	8.5
Mathematics	0.4	0.6	0.8	0.8	0.7	0.7	0.8	0.9	1.0	1.0	0.8	1.6
Computer sciences	NA	NA	NA	0.0	0.0	0.1	0.1	0.2	0.2	0.1	0.2	0.3
Environmental sciences	0.4	0.5	0.6	0.7	0.8	0.8	1.0	1.2	1.2	1.5	1.9	1.7
Life sciences	5.4	6.3	7.7	9.7	10.4	11.4	13.1	13.1	15.5	15.8	17.4	18.8
Psychology	1.4	1.9	2.3	3.4	3.7	3.7	4.6	4.5	4.8	4.4	5.5	6.1
Social sciences	1.8	2.5	2.3	3.3	3.2	4.4	5.8	4.5	5.5	5.8	5.2	5.4
Engineering	1.1	1.2	1.3	1.5	1.4	1.7	2.0	1.9	2.6	2.7	3.0	3.8

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Appendix table 5-25.

Academic employment of doctoral scientists and engineers, by degree field, race/ethnicity, and type of position: 1973-95
(Thousands)

Field and race/ethnicity	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995
White non-Hispanic, total S&E	12.9	15.4	17.2	21.3	21.9	23.9	28.8	26.7	31.3	31.7	33.1	35.5
Total sciences	12.0	14.4	16.2	20.1	20.5	22.7	27.2	25.4	29.4	29.7	31.2	33.2
Physical sciences	3.6	4.0	4.1	3.9	3.9	4.1	4.7	4.0	4.8	4.9	5.4	6.0
Mathematics	0.4	0.6	0.7	0.7	0.6	0.6	0.8	0.8	0.9	0.8	0.6	1.3
Computer sciences	NA	NA	NA	0.0	0.0	0.1	0.1	0.2	0.1	0.1	0.2	0.2
Environmental sciences	0.4	0.4	0.5	0.7	0.7	0.8	0.9	1.1	1.0	1.4	1.7	1.4
Life sciences	4.7	5.4	6.7	8.5	8.9	9.7	11.4	11.3	13.2	13.2	14.0	14.6
Psychology	1.3	1.8	2.2	3.2	3.4	3.4	4.2	4.1	4.4	4.0	4.9	5.2
Social sciences	1.6	2.2	2.0	3.0	3.0	4.0	5.1	4.0	5.0	5.3	4.5	4.7
Engineering	0.8	1.0	1.0	1.3	1.4	1.2	1.7	1.3	1.9	2.0	1.9	2.3
Asian, total S&E	1.1	1.5	1.7	2.1	2.5	2.7	3.2	3.3	4.0	4.2	6.1	8.0
Total sciences	1.0	1.3	1.5	1.9	2.4	2.2	2.9	2.8	3.3	3.6	5.1	6.6
Physical sciences	0.5	0.5	0.6	0.6	0.8	0.7	1.0	1.0	1.1	0.9	1.6	2.1
Mathematics	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.2
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Environmental sciences	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.3
Life sciences	0.4	0.6	0.8	1.0	1.4	1.2	1.3	1.4	1.7	2.1	2.7	3.4
Psychology	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Social sciences	0.0	0.1	0.1	0.2	0.1	0.1	0.4	0.2	0.2	0.2	0.3	0.3
Engineering	0.1	0.1	0.2	0.2	0.1	0.4	0.3	0.5	0.7	0.6	1.0	1.3
Underrep. minorities, total S&E[a]	0.4	0.5	0.5	0.7	0.8	1.1	1.4	1.5	1.7	1.5	2.3	2.8
Total sciences	0.3	0.5	0.5	0.6	0.8	1.0	1.3	1.4	1.6	1.4	2.2	2.7
Physical sciences	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.2	0.4	0.4
Mathematics	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.2
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Environmental sciences	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Life sciences	0.2	0.2	0.2	0.2	0.2	0.4	0.4	0.5	0.6	0.5	0.8	0.9
Psychology	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.5	0.7
Social sciences	0.0	0.1	0.1	0.1	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4
Engineering	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Black, total S&E	0.2	0.3	0.3	0.3	0.4	0.6	0.6	0.7	0.6	0.6	1.0	1.3
Total sciences	0.2	0.3	0.2	0.3	0.4	0.6	0.6	0.7	0.5	0.5	1.0	1.3
Physical sciences	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1
Mathematics	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Environmental sciences	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Life sciences	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.4
Psychology	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.1	0.3	0.4
Social sciences	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.2	0.1	0.2
Engineering	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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Appendix table 5-25.

Academic employment of doctoral scientists and engineers, by degree field, race/ethnicity, and type of position: 1973-95

(Thousands)

Field and race/ethnicity	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995
Hispanic, total S&E	0.2	0.2	0.3	0.4	0.4	0.5	0.7	0.7	1.0	0.8	1.0	1.3
Total sciences	0.2	0.2	0.2	0.3	0.4	0.4	0.6	0.6	0.9	0.8	0.9	1.2
Physical sciences	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.2	0.2	0.2	0.2
Mathematics	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Environmental sciences	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Life sciences	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.4	0.3	0.4	0.4
Psychology	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.2	0.2
Social sciences	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.2	0.1
Engineering	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.1	0.0	0.1	0.1
Native American, total S&E	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2
Total sciences	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.2
Physical sciences	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Mathematics	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Computer sciences	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Environmental sciences	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Life sciences	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Psychology	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Social sciences	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Engineering	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

NA = not available

NOTES: Data exclude university-managed federally funded research and development centers. Due to survey coverage, the data also exclude scientists and engineers with doctorates from foreign institutions. Field of employment data were discontinued after the 1991 survey and are not shown. Faculty positions include full, associate, and assistant professors and instructors. Details may not add to totals because of rounding and the inclusion of Hispanic respondents in different racial categories.

*Underrepresented minorities in science and engineering are blacks, Hispanics, and Native Americans.

SOURCE: National Science Foundation, Science Resources Studies Division, *Characteristics of Doctoral Scientists and Engineers in the United States: 1995*, Detailed Statistical Tables, NSF 97-333 (Arlington, VA: 1997).

Appendix table 5-26.

Age distribution of academic doctoral scientists and engineers, by type of appointment: 1973-95

(Percentages)

	Total	35 and younger	36-45 years old	46-55 years old	56-65 years old	65 and older
All doctoral scientists and engineers						
1973	100.0	33.0	33.4	22.1	9.9	1.6
1975	100.0	30.7	34.8	22.7	10.3	1.5
1977	100.0	28.6	36.1	22.7	11.2	1.4
1979	100.0	24.0	39.0	23.1	12.2	1.6
1981	100.0	22.4	39.3	22.5	13.8	2.1
1983	100.0	18.6	40.5	23.9	14.4	2.6
1985	100.0	17.4	39.8	25.2	14.7	2.8
1987	100.0	15.9	37.6	28.5	15.2	2.8
1989	100.0	15.2	34.9	31.0	15.8	3.1
1991	100.0	14.8	34.3	32.4	15.7	2.8
1993	100.0	16.3	33.9	32.8	14.8	2.3
1995	100.0	15.7	33.2	32.8	15.7	2.6
Full-time faculty						
1973	100.0	30.4	34.6	23.2	10.2	1.5
1975	100.0	27.8	36.2	23.9	10.6	1.5
1977	100.0	25.2	37.3	24.2	11.9	1.4
1979	100.0	20.2	40.2	24.8	13.1	1.7
1981	100.0	18.5	40.3	24.3	14.8	2.2
1983	100.0	14.8	41.1	25.8	15.7	2.6
1985	100.0	14.1	40.3	27.0	15.9	2.8
1987	100.0	12.1	37.6	30.7	16.8	2.9
1989	100.0	10.9	34.7	33.7	17.6	3.0
1991	100.0	11.6	33.6	34.9	17.1	2.8
1993	100.0	11.9	33.8	35.4	16.4	2.5
1995	100.0	10.9	32.8	35.7	17.8	2.8
All other types of appointment						
1973	100.0	54.6	23.3	12.9	6.8	2.4
1975	100.0	52.0	24.3	14.1	7.6	1.9
1977	100.0	53.9	27.0	11.3	6.1	1.7
1979	100.0	49.7	31.2	11.6	6.2	1.3
1981	100.0	47.5	32.8	11.5	7.1	1.2
1983	100.0	43.0	36.8	11.6	5.9	2.7
1985	100.0	35.4	37.5	15.6	8.3	3.1
1987	100.0	38.7	37.5	15.6	6.0	2.3
1989	100.0	37.6	35.9	17.0	6.4	3.1
1991	100.0	30.9	37.4	19.9	8.7	3.0
1993	100.0	35.8	34.1	21.5	7.3	1.4
1995	100.0	35.4	35.1	20.6	7.0	1.8

NOTES: Faculty positions include full, associate, and assistant professors and instructors. Details may not add to totals because of rounding.

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Doctorate Recipients, unpublished tabulations (1997).

See figure 5-12.

Science & Engineering Indicators – 1998

Appendix table 5-27.

Age distribution of full-time doctoral S&E faculty at research universities and other academic institutions: 1973-95

Age bracket	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995
All universities and colleges												
Total number (thousands)	*103.3*	*116.4*	*125.6*	*131.2*	*142.0*	*148.4*	*156.9*	*164.5*	*169.8*	*173.1*	*172.4*	*171.4*
Under 30 (%)	7.1	5.0	4.5	3.4	3.1	2.2	1.9	1.3	1.5	1.5	2.1	1.6
31-35 (%)	23.2	22.8	20.5	16.7	15.2	12.5	12.0	10.5	9.4	10.2	9.8	9.0
36-40 (%)	18.8	20.2	21.8	23.4	21.5	19.8	19.0	17.1	16.1	15.4	16.0	15.7
41-45 (%)	16.1	16.3	15.6	16.8	19.0	21.7	21.7	20.6	18.7	18.4	17.5	17.0
46-50 (%)	13.1	13.0	13.6	13.6	13.1	14.1	15.4	18.7	20.7	19.6	19.1	17.5
51-55 (%)	10.2	10.9	10.9	11.6	11.5	12.1	11.9	12.3	13.4	15.6	16.4	18.4
56-60 (%)	6.3	6.6	7.7	8.2	9.2	9.6	9.1	10.2	10.5	10.5	9.9	11.3
61-65 (%)	3.9	4.0	4.3	4.9	5.6	6.1	6.6	6.5	7.1	6.4	6.7	6.6
66+ (%)	1.3	1.2	1.1	1.4	1.8	2.0	2.4	2.7	2.7	2.4	2.5	2.8
Research universities[a]												
Total number (thousands)	*55.7*	*61.4*	*64.7*	*67.1*	*73.8*	*72.2*	*80.6*	*84.2*	*86.6*	*85.8*	*84.3*	*81.6*
Under 30 (%)	6.7	4.9	4.6	3.9	4.2	2.8	2.5	1.6	1.9	1.5	2.3	1.6
31-35 (%)	21.7	21.6	19.3	17.3	15.4	12.8	13.4	12.4	11.0	11.4	11.1	9.4
36-40 (%)	18.2	19.1	20.2	20.7	20.5	19.4	18.3	17.0	17.5	17.3	17.4	17.5
41-45 (%)	16.4	15.8	14.8	16.8	17.6	19.2	19.7	19.1	17.2	17.4	17.2	17.9
46-50 (%)	13.7	13.7	14.4	13.6	12.5	13.8	14.6	17.1	17.6	18.1	17.8	16.2
51-55 (%)	10.7	11.9	11.9	12.2	11.3	11.9	11.9	11.5	13.1	14.2	14.5	16.0
56-60 (%)	6.9	7.2	8.5	8.8	10.1	10.5	9.2	10.4	10.6	10.5	9.8	11.3
61-65 (%)	4.4	4.5	5.1	5.2	6.2	7.2	7.7	7.6	7.6	6.6	7.0	6.7
66+ (%)	1.4	1.4	1.3	1.6	2.2	2.3	2.7	3.3	3.5	3.1	2.9	3.5
Other types of universities and colleges												
Total number (thousands)	*47.6*	*54.9*	*60.9*	*64.2*	*68.2*	*76.2*	*76.3*	*80.2*	*83.2*	*87.2*	*88.1*	*89.7*
Under 30 (%)	7.6	5.1	4.3	2.8	2.0	1.7	1.3	1.0	1.0	1.5	1.8	1.6
31-35 (%)	24.9	24.0	21.9	16.1	14.9	12.1	10.5	8.6	7.7	9.0	8.6	8.6
36-40 (%)	19.6	21.4	23.6	26.3	22.7	20.1	19.7	17.3	14.6	13.6	14.8	14.2
41-45 (%)	15.7	16.8	16.5	16.8	20.5	24.1	23.8	22.1	20.2	19.3	17.9	16.2
46-50 (%)	12.5	12.3	12.8	13.7	13.6	14.4	16.1	20.5	23.8	21.1	20.4	18.8
51-55 (%)	9.5	9.8	9.8	11.0	11.7	12.3	11.9	13.0	13.8	17.0	18.2	20.5
56-60 (%)	5.7	5.9	6.8	7.6	8.3	8.6	8.9	9.9	10.5	10.6	9.9	11.4
61-65 (%)	3.2	3.5	3.5	4.6	4.9	5.0	5.6	5.4	6.5	6.2	6.3	6.5
66+ (%)	1.3	1.1	0.8	1.1	1.3	1.6	2.1	2.1	1.8	1.7	2.1	2.2

NOTES: Faculty positions include full, associate, and assistant professors and instructors. Italics = rounded numbers; all other numbers are percentages.

[a] Research universities are designated by Carnegie classification code (see Carnegie Foundation for the Advancement of Teaching, *A Classification of Institutions of Higher Education*, 1994 ed., Princeton: Princeton University Press, 1994).

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Doctorate Recipients, unpublished tabulations (1997).

See figure 5-13.

Science & Engineering Indicators – 1998

Appendix table 5-28.

Employment sector of recent S&E Ph.D.s, by sex and race/ethnicity: 1973-95

(Thousands)

Sector	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995
All recent S&E Ph.D.s												
Total	45.4	45.0	43.2	40.7	42.0	42.7	43.8	44.8	47.8	53.6	49.7	52.1
Academia	25.0	23.4	22.5	20.9	20.7	20.5	21.8	21.1	23.3	25.5	25.1	26.9
Business	8.6	9.9	9.0	8.8	11.6	12.0	11.5	9.5	10.6	12.7	12.4	13.6
Government	4.5	4.3	4.1	3.9	3.3	3.7	3.2	3.4	3.3	3.5	4.0	4.1
FFRDCs	2.1	2.0	1.9	1.6	1.3	0.8	1.6	1.5	1.6	2.2	2.1	1.6
All other	5.1	5.4	5.6	5.5	5.1	5.5	5.7	9.2	9.0	9.5	6.1	5.9
Men												
Total	40.8	39.1	36.4	33.2	32.6	32.3	32.2	32.2	34.0	37.0	33.9	34.0
Academia	21.9	19.5	18.2	16.4	15.5	14.7	15.5	14.9	16.1	16.7	16.8	16.7
Business	8.4	9.5	8.3	7.9	10.0	10.0	9.4	8.0	8.7	10.3	9.6	10.5
Government	4.2	3.9	3.6	3.3	2.6	2.9	2.4	2.4	2.4	2.6	2.6	2.6
FFRDCs	2.0	1.9	1.8	1.5	1.2	0.7	1.4	1.3	1.4	1.9	1.6	1.2
All other	4.2	4.4	4.4	4.0	3.4	3.8	3.4	5.6	5.4	5.4	3.2	3.0
Women												
Total	4.6	5.8	6.8	7.5	9.4	10.4	11.6	12.6	13.8	16.6	15.8	18.1
Academia	3.1	3.9	4.3	4.5	5.2	5.8	6.3	6.2	7.3	8.8	8.3	10.2
Business	0.3	0.4	0.7	0.9	1.6	2.0	2.1	1.6	1.9	2.4	2.8	3.0
Government	0.3	0.4	0.5	0.6	0.7	0.9	0.8	1.0	0.9	0.9	1.4	1.5
FFRDCs	0.0	0.1	0.1	0.1	0.2	0.1	0.2	0.3	0.2	0.3	0.5	0.4
All other	0.8	1.0	1.3	1.4	1.7	1.7	2.3	3.6	3.6	4.1	2.9	3.0
Whites												
Total	40.6	38.5	36.4	34.4	35.3	35.4	36.1	36.2	37.3	40.2	36.1	35.9
Academia	22.8	20.4	19.5	18.1	18.0	17.3	18.1	17.2	18.3	19.5	18.0	18.8
Business	7.4	7.9	6.9	6.7	8.9	9.4	9.2	7.4	7.9	8.5	7.8	8.2
Government	4.2	3.8	3.6	3.5	2.9	3.3	2.6	2.9	2.8	2.9	3.4	3.2
FFRDCs	1.9	1.8	1.6	1.3	1.1	0.7	1.5	1.4	1.3	1.9	1.7	1.2
All other	4.4	4.5	4.8	4.7	4.3	4.5	4.7	7.2	7.0	7.3	5.2	4.6
Asians												
Total	2.8	4.1	4.5	4.2	4.8	4.9	5.2	6.0	7.5	9.9	10.6	12.6
Academia	1.2	1.6	1.7	1.6	1.7	2.1	2.4	2.5	3.3	4.1	5.4	6.2
Business	1.0	1.6	1.8	1.8	2.4	2.1	1.8	1.7	2.3	3.5	3.9	4.7
Government	0.2	0.2	0.2	0.2	0.2	0.1	0.4	0.2	0.3	0.4	0.4	0.6
FFRDCs	0.1	0.1	0.2	0.2	0.2	0.0	0.1	0.1	0.2	0.3	0.3	0.4
All other	0.4	0.5	0.6	0.5	0.5	0.6	0.5	1.4	1.3	1.6	0.6	0.8
Underrepresented minorities[a]												
Total	1.0	1.6	1.7	2.0	1.8	2.3	2.3	2.5	3.0	3.4	3.0	3.5
Academia	0.6	0.9	1.0	1.1	0.9	1.1	1.2	1.3	1.7	1.8	1.7	1.9
Business	0.1	0.2	0.2	0.3	0.2	0.5	0.4	0.4	0.4	0.7	0.6	0.7
Government	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
FFRDCs	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.0
All other	0.2	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.7	0.6	0.3	0.5

FFRDC = federally funded research and development center

NOTES: Recent Ph.D.s are those who have earned their doctorate within the three preceding years. Details may not add to totals because of rounding.

[a] Underrepresented minorities in science and engineering are blacks, Hispanics, and Native Americans. Data on race/ethnicity exclude unknown cases and do not add to total.

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Doctorate Recipients, unpublished tabulations (1997).

Science & Engineering Indicators – 1998

Appendix table 5-29.

Recent S&E Ph.D.s employed in higher education, by field and type of appointment: 1973-95

(Thousands)

Appointment	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995
Science & engineering												
Total	25.0	23.4	22.5	20.9	20.7	20.5	21.8	21.1	23.3	25.5	25.1	26.9
Faculty	18.8	16.8	15.0	12.8	12.0	11.8	12.5	11.0	11.4	14.4	12.4	11.6
Postdoctorate	3.2	4.3	5.2	5.2	5.9	5.7	6.0	6.3	7.8	7.0	8.4	10.7
Other	2.1	1.5	1.4	2.6	2.6	2.3	3.0	3.5	3.7	3.4	4.3	4.6
Physical sciences												
Total	4.1	3.1	3.0	2.2	2.2	2.0	2.5	2.4	2.9	2.9	3.4	3.8
Faculty	1.9	1.2	1.2	0.8	0.7	0.6	0.8	0.7	0.8	1.0	0.9	0.7
Postdoctorate	1.3	1.4	1.5	1.1	1.3	1.1	1.5	1.4	1.7	1.4	2.1	2.4
Other	0.6	0.3	0.2	0.2	0.2	0.3	0.2	0.3	0.3	0.4	0.3	0.6
Mathematics												
Total	2.3	1.9	1.8	1.3	1.1	1.1	1.1	1.1	1.1	1.6	1.6	1.2
Faculty	2.2	1.7	1.5	1.2	1.0	1.0	1.0	0.8	0.9	1.3	1.4	0.8
Postdoctorate	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.0	0.3
Other	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.2	0.1	0.2
Computer sciences												
Total	NA	NA	NA	0.1	0.3	0.2	0.4	0.5	0.6	0.7	0.7	0.8
Faculty	NA	NA	NA	0.1	0.2	0.2	0.3	0.4	0.6	0.7	0.6	0.6
Postdoctorate	NA	NA	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Other	NA	NA	NA	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.1
Environmental sciences												
Total	0.7	0.8	0.7	0.6	0.6	0.6	0.6	0.8	0.6	0.7	0.7	0.9
Faculty	0.5	0.6	0.4	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.2	0.3
Postdoctorate	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.2	0.2	0.2	0.3	0.4
Other	0.1	0.1	0.0	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.2
Life sciences												
Total	7.1	6.9	6.6	6.7	7.3	7.4	7.4	7.4	8.2	9.0	8.8	10.2
Faculty	4.6	4.0	3.2	2.8	2.9	3.1	2.8	2.6	2.5	3.4	2.5	3.0
Postdoctorate	1.5	2.2	2.8	3.2	3.6	3.5	3.4	3.6	4.4	4.4	4.8	5.6
Other	0.6	0.4	0.4	0.7	0.8	0.7	1.0	1.0	1.2	0.9	1.5	1.5
Psychology												
Total	2.6	2.8	3.0	3.1	2.9	2.7	3.0	2.7	2.9	2.8	2.6	2.9
Faculty	2.2	2.3	2.3	2.0	1.7	1.8	1.7	1.4	1.5	1.8	1.4	1.5
Postdoctorate	0.1	0.3	0.3	0.4	0.5	0.3	0.5	0.4	0.6	0.3	0.2	0.7
Other	0.2	0.2	0.2	0.6	0.6	0.4	0.7	0.8	0.8	0.6	1.0	0.8
Social sciences												
Total	5.8	5.9	5.5	5.3	4.9	4.5	4.6	4.0	4.0	4.5	4.3	4.0
Faculty	5.5	5.4	5.0	4.5	4.0	3.5	3.6	3.1	2.8	3.7	3.4	3.1
Postdoctorate	0.1	0.1	0.1	0.2	0.2	0.3	0.2	0.0	0.2	0.1	0.1	0.2
Other	0.2	0.3	0.3	0.5	0.7	0.5	0.8	0.8	0.9	0.6	0.8	0.7
Engineering												
Total	2.4	1.9	1.9	1.6	1.4	2.0	2.3	2.3	3.0	3.3	3.0	3.2
Faculty	2.0	1.5	1.4	1.2	1.2	1.4	1.9	1.6	2.0	2.3	1.9	1.6
Postdoctorate	0.1	0.2	0.3	0.2	0.2	0.3	0.2	0.4	0.5	0.4	0.7	1.0
Other	0.3	0.2	0.1	0.3	0.1	0.2	0.1	0.3	0.4	0.5	0.4	0.6

NA = not available

NOTES: Recent Ph.D.s are those who have earned their doctorate within the three preceding years. Details may not add to totals because of rounding.

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Doctorate Recipients, unpublished tabulations (1997).

See figure 5-15.

Science & Engineering Indicators – 1998

Appendix table 5-30.

Recent S&E Ph.D.s employed in higher education, by sex, race/ethnicity, and type of appointment: 1973-95

(Thousands)

Appointment	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995
All recent S&E Ph.D.s												
Total	25.0	23.4	22.5	20.9	20.7	20.5	21.8	21.1	23.3	25.5	25.1	26.9
Faculty	18.8	16.8	15.0	12.8	12.0	11.8	12.5	11.0	11.4	14.4	12.4	11.6
Postdoctorate	3.2	4.3	5.2	5.2	5.9	5.7	6.0	6.3	7.8	7.0	8.4	10.7
Other	2.1	1.5	1.4	2.6	2.6	2.3	3.0	3.5	3.7	3.4	4.3	4.6
Men												
Total	21.9	19.5	18.2	16.4	15.5	14.7	15.5	14.9	16.1	16.7	16.8	16.7
Faculty	16.7	14.2	12.3	10.0	9.2	8.8	9.0	7.9	7.9	9.6	8.3	7.0
Postdoctorate	2.8	3.4	4.2	4.1	4.4	4.1	4.2	4.7	5.7	4.7	6.0	6.9
Other	1.6	1.2	1.1	2.1	1.8	1.5	2.0	2.2	2.2	1.9	2.5	2.8
Women												
Total	3.1	3.9	4.3	4.5	5.2	5.8	6.3	6.2	7.3	8.8	8.3	10.2
Faculty	2.1	2.6	2.8	2.8	2.8	3.0	3.5	3.2	3.5	4.8	4.1	4.6
Postdoctorate	0.4	0.8	1.0	1.1	1.5	1.6	1.7	1.6	2.2	2.3	2.4	3.7
Other	0.4	0.3	0.3	0.5	0.8	0.8	1.1	1.3	1.5	1.5	1.9	1.9
Whites												
Total	22.8	20.4	19.5	18.1	18.0	17.3	18.1	17.2	18.3	19.5	18.0	18.8
Faculty	17.3	14.9	13.3	11.1	10.7	10.1	10.4	9.2	9.2	11.3	9.2	9.0
Postdoctorate	2.8	3.4	4.2	4.4	4.8	4.8	4.9	4.9	5.9	4.8	5.4	6.6
Other	1.9	1.3	1.2	2.3	2.3	1.8	2.6	3.0	2.9	2.7	3.5	3.2
Asians												
Total	1.2	1.6	1.7	1.6	1.7	2.1	2.4	2.5	3.3	4.1	5.4	6.2
Faculty	0.6	0.7	0.7	0.8	0.5	1.0	1.3	1.0	1.3	1.8	2.1	1.7
Postdoctorate	0.3	0.7	0.8	0.6	0.9	0.7	0.8	1.1	1.4	1.8	2.6	3.5
Other	0.1	0.1	0.1	0.2	0.2	0.4	0.3	0.3	0.4	0.5	0.6	1.0
Underrepresented minorities[a]												
Total	0.6	0.9	1.0	1.1	0.9	1.1	1.2	1.3	1.7	1.8	1.7	1.9
Faculty	0.4	0.8	0.8	0.9	0.7	0.7	0.7	0.7	0.9	1.3	1.0	0.9
Postdoctorate	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.3	0.4	0.6
Other	0.1	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.2	0.3	0.4

NOTES: Recent Ph.D.s are those who have earned their doctorate within the three preceding years. Details may not add to totals because of rounding.

[a] Underrepresented minorities in science and engineering are blacks, Hispanics, and Native Americans.

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Doctorate Recipients, unpublished tabulations (1997).

See figure 5-15.

Appendix table 5-31.

Academic doctoral scientists and engineers, by self-reported primary work responsibility and type of employing institution: 1973-95

(Thousands)

	All academic institutions			Research universities[a]			Other universities and colleges		
	Teaching	Research	Other	Teaching	Research	Other	Teaching	Research	Other
				Number (thousands)					
1973	73.3	27.8	16.9	32.3	17.5	7.8	41.0	10.3	9.2
1975	83.9	30.8	19.4	36.5	19.0	7.8	47.3	11.8	11.6
1977	82.2	37.0	26.3	33.3	21.9	12.4	48.9	15.1	13.8
1979	83.9	41.3	30.2	33.6	23.3	14.4	50.3	17.9	15.9
1981	95.9	46.5	24.6	39.6	28.1	10.8	56.3	18.4	13.8
1983	97.7	48.9	29.6	36.2	28.2	12.7	61.5	20.6	16.9
1985	101.1	56.0	33.3	37.4	34.9	13.2	63.7	21.1	20.1
1987	99.4	66.5	30.1	35.1	42.5	13.6	64.2	24.0	16.5
1989	101.0	72.2	33.6	34.4	45.0	14.4	66.5	27.2	19.1
1991	103.4	73.9	33.2	33.5	45.9	14.1	69.9	28.1	19.2
1993	98.3	80.2	35.2	31.6	46.5	14.7	66.8	33.7	20.5
1995	100.2	83.0	34.3	30.5	45.9	13.7	69.7	37.1	20.7
				Percent					
1973	62	24	14	56	30	13	68	17	15
1975	63	23	14	58	30	12	67	17	16
1977	57	25	18	49	32	18	63	19	18
1979	54	27	19	47	33	20	60	21	19
1981	57	28	15	50	36	14	64	21	16
1983	55	28	17	47	37	16	62	21	17
1985	53	29	17	44	41	15	61	20	19
1987	51	34	15	38	47	15	61	23	16
1989	49	35	16	37	48	15	59	24	17
1991	49	35	16	36	49	15	60	24	16
1993	46	38	16	34	50	16	55	28	17
1995	46	38	16	34	51	15	55	29	16

NOTE: Details may not add to totals because of rounding.

[a] Research universities are designated by Carnegie classification code (see Carnegie Foundation for the Advancement of Teaching, *A Classification of Institutions of Higher Education*, 1994 ed., Princeton: Princeton University Press, 1994).

SOURCE: National Science Foundation, Survey of Doctorate Recipients, unpublished tabulations (1997).

Science & Engineering Indicators – 1998

Appendix table 5-32.

Academic doctoral scientists and engineers with work responsibility for R&D, by degree field: 1973-95

Field	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995
Total employment (thousands)												
Total science & engineering	118.0	134.1	145.5	155.4	167.1	176.2	190.3	196.0	206.7	210.6	213.8	217.5
Total sciences	105.6	120.7	130.7	139.5	151.0	158.1	170.4	174.8	183.9	187.8	190.6	193.7
Physical sciences	22.1	23.6	25.0	24.6	25.4	25.1	27.0	27.2	27.7	27.7	28.6	29.3
Mathematics	9.7	11.0	11.7	12.2	12.4	12.9	13.6	13.8	14.5	15.2	15.5	14.6
Computer sciences	NA	NA	NA	0.1	0.3	0.5	0.8	1.1	1.5	2.0	2.5	3.1
Environmental sciences	3.4	3.9	4.2	4.2	4.6	4.8	5.2	5.6	5.9	6.0	6.4	6.4
Life sciences	34.9	39.4	42.6	47.0	51.3	54.9	58.7	61.3	64.8	66.9	68.2	71.6
Psychology	12.2	14.8	16.2	17.7	20.1	21.0	23.1	23.7	25.0	25.2	25.0	26.1
Social sciences	23.4	28.0	31.1	33.6	36.9	38.9	42.0	42.2	44.5	44.8	44.4	42.5
Engineering	12.4	13.4	14.8	15.8	16.1	18.1	19.9	21.2	22.9	22.8	23.1	23.8
Active in R&D (thousands)												
Total science & engineering	82.3	90.6	85.0	90.0	104.5	106.7	114.7	143.9	151.6	156.6	150.1	153.5
Total sciences	73.3	81.6	76.1	80.2	94.3	95.1	101.9	127.2	133.9	138.4	132.6	135.0
Physical sciences	16.3	16.9	16.3	15.4	16.8	16.3	17.5	20.2	20.8	20.8	20.0	20.6
Mathematics	6.8	7.5	6.8	6.9	7.3	7.7	7.7	9.7	10.2	10.7	9.5	9.4
Computer sciences	NA	NA	NA	0.1	0.3	0.4	0.5	1.0	1.3	1.7	2.0	2.4
Environmental sciences	2.5	2.8	2.9	2.7	3.3	3.3	3.8	4.6	4.9	5.1	5.0	5.1
Life sciences	26.0	29.0	28.7	32.1	36.7	38.2	39.6	48.8	51.8	53.3	51.8	53.8
Psychology	7.3	8.5	7.7	8.3	10.5	10.7	10.9	14.3	14.3	15.7	14.9	15.6
Social sciences	14.3	16.9	13.8	14.7	19.6	18.6	22.0	28.6	30.5	31.1	29.3	28.1
Engineering	9.0	9.0	8.9	9.8	10.2	11.6	12.8	16.7	17.7	18.2	17.5	18.5
Percentage active in R&D												
Total science & engineering	70	68	58	58	63	61	60	73	73	74	70	71
Total sciences	69	68	58	57	62	60	60	73	73	74	70	70
Physical sciences	74	72	65	63	66	65	65	74	75	75	70	70
Mathematics	70	68	58	57	59	59	57	70	71	71	61	64
Computer sciences	NA	NA	NA	86	95	72	69	90	89	86	79	76
Environmental sciences	72	73	69	65	72	69	73	83	84	84	78	80
Life sciences	75	74	67	68	71	70	67	80	80	80	76	75
Psychology	60	57	48	47	52	51	47	60	57	62	60	60
Social sciences	61	60	44	44	53	48	52	68	68	69	66	66
Engineering	73	67	60	62	63	64	64	79	77	80	76	78

NA = not available

NOTES: Data exclude university-managed federally funded research and development centers. Due to survey coverage, the data also exclude scientists and engineers with doctorates from foreign institutions. All data are based on degree field. Those who are "active in R&D" reported a primary or secondary work responsibility for R&D. For 1981-87, counts are lower bound estimates because a fraction of academic respondents was not asked about secondary work responsibility (15 percent in 1981, 6 percent in 1983, 13 percent in 1985, and fewer than 1 percent in 1987). Details may not add to totals because of rounding.

SOURCE: National Science Foundation, Science Resources Studies Division, *Characteristics of Doctoral Scientists and Engineers in the United States: 1995*, Detailed Statistical Tables, NSF 97-333 (Arlington, VA: 1997).

See figure 5-16.

Appendix table 5-33.

Academic doctoral scientists and engineers reporting federal support from one or more agencies, by field: 1973-95

(Percentages)

	1973	1975	1977	1979	1981	1983	*1985*[a]	1987	1989	1991	*1993*[a]	*1995*[a]
Total science & engineering												
Total number employed	118,000	134,100	145,500	155,400	167,100	176,200	*190,300*	196,000	206,700	210,600	*213,800*	*217,500*
Percentage supported	46	42	41	39	42	44	*37*	48	49	50	*37*	*39*
Funding from 1 agency	80	80	81	82	81	80	*82*	74	74	70	*75*	*73*
Funding from 2 agencies	17	16	15	15	16	17	*16*	20	20	23	*20*	*21*
Funding from 3+ agencies	4	4	3	3	3	3	*3*	6	6	7	*5*	*5*
Total sciences												
Total number employed	105,600	120,700	130,700	139,600	151,000	158,100	*170,400*	174,800	183,800	187,800	*190,700*	*193,700*
Percentage supported	45	41	40	38	41	43	*36*	47	48	49	*36*	*38*
Funding from 1 agency	81	81	82	83	82	81	*82*	75	75	72	*76*	*75*
Funding from 2 agencies	16	16	15	14	15	17	*15*	20	19	22	*19*	*20*
Funding from 3+ agencies	3	3	3	2	3	3	*3*	5	5	6	*5*	*5*
Physical sciences												
Total number employed	22,100	23,600	25,000	24,600	25,400	25,100	*27,000*	27,200	27,700	27,700	*28,600*	*29,300*
Percentage supported	49	45	46	44	50	51	*43*	54	58	56	*46*	*48*
Funding from 1 agency	77	75	77	77	76	74	*78*	68	69	63	*68*	*66*
Funding from 2 agencies	20	21	19	20	17	23	*18*	24	24	30	*26*	*28*
Funding from 3+ agencies	3	4	4	3	7	3	*3*	8	7	7	*6*	*7*
Mathematics												
Total number employed	9,700	11,000	11,700	12,200	12,400	12,900	*13,600*	13,800	14,500	15,200	*15,500*	*14,600*
Percentage supported	29	19	19	21	21	30	*21*	31	33	34	*19*	*22*
Funding from 1 agency	90	89	88	86	83	89	*84*	78	74	75	*80*	*75*
Funding from 2 agencies	8	10	11	14	15	9	*15*	19	22	19	*16*	*21*
Funding from 3+ agencies	2	1	1	0	2	2	*1*	3	4	6	*4*	*3*
Computer sciences												
Total number employed	NA	NA	NA	100	300	500	*800*	1,100	1,500	2,000	*2,500*	*3,100*
Percentage supported	NA	NA	NA	35	30	45	*45*	62	52	49	*40*	*43*
Funding from 1 agency	NA	NA	NA	100	86	72	*78*	65	63	58	*58*	*63*
Funding from 2 agencies	NA	NA	NA	0	14	28	*22*	30	34	38	*37*	*33*
Funding from 3+ agencies	NA	NA	NA	0	0	0	*0*	5	3	3	*5*	*5*
Environmental sciences												
Total number employed	3,400	3,900	4,200	4,200	4,600	4,800	*5,200*	5,600	5,900	6,000	*6,400*	*6,400*
Percentage supported	47	46	43	45	49	54	*51*	60	63	65	*51*	*54*
Funding from 1 agency	63	65	65	73	63	58	*62*	55	54	48	*55*	*54*
Funding from 2 agencies	29	27	24	19	26	30	*27*	29	32	33	*29*	*35*
Funding from 3+ agencies	7	8	10	9	11	12	*11*	16	14	19	*16*	*11*

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Appendix table 5-33.

Academic doctoral scientists and engineers reporting federal support from one or more agencies, by field: 1973-95

(Percentages)

	1973	1975	1977	1979	1981	1983	*1985*[a]	1987	1989	1991	*1993*[a]	*1995*[a]
Life sciences												
Total number employed	34,900	39,400	42,600	47,000	51,300	54,900	*58,700*	61,300	64,800	66,900	*68,200*	*71,600*
Percentage supported	60	59	57	55	59	59	*53*	65	65	65	*52*	*52*
Funding from 1 agency	82	83	84	85	84	82	*84*	76	76	74	*81*	*79*
Funding from 2 agencies	15	15	14	13	14	16	*14*	19	18	20	*16*	*17*
Funding from 3+ agencies	3	3	3	2	2	2	*2*	5	5	6	*4*	*5*
Psychology												
Total number employed	12,200	14,800	16,200	17,700	20,100	21,000	*23,100*	23,700	25,000	25,200	*25,000*	*26,100*
Percentage supported	39	36	33	32	32	30	*25*	31	35	35	*26*	*27*
Funding from 1 agency	85	84	86	86	81	84	*84*	84	81	80	*81*	*85*
Funding from 2 agencies	13	13	12	12	17	15	*15*	14	15	15	*16*	*13*
Funding from 3+ agencies	2	3	2	2	2	2	*1*	3	4	5	*3*	*2*
Social sciences												
Total number employed	23,400	28,000	31,100	33,600	36,900	38,900	*42,000*	42,200	44,500	44,800	*44,400*	*42,500*
Percentage supported	26	24	23	20	21	24	*17*	27	28	28	*14*	*16*
Funding from 1 agency	84	86	87	88	86	89	*89*	79	84	73	*76*	*81*
Funding from 2 agencies	11	12	12	11	14	9	*8*	16	13	22	*21*	*17*
Funding from 3+ agencies	4	3	1	1	0	2	*2*	4	3	5	*3*	*2*
Engineering												
Total number employed	12,400	13,400	14,800	15,800	16,100	18,100	*19,900*	21,200	22,900	22,800	*23,100*	*23,800*
Percentage supported	55	50	51	49	50	55	*42*	57	56	63	*43*	*50*
Funding from 1 agency	70	71	74	72	75	72	*76*	66	63	60	*64*	*61*
Funding from 2 agencies	24	22	20	23	19	20	*19*	24	24	28	*28*	*30*
Funding from 3+ agencies	6	7	6	5	6	8	*5*	9	13	13	*8*	*9*

NA = not available

[a] Data are not comparable to other years that had reference periods of a total academic year: 1985 data reference support in a single month; 1993 and 1995 data reference support in a single week. Details may not add to totals because of rounding.

SOURCE: National Science Foundation, Science Resources Studies Division, unpublished tabulations (1997).

Appendix table 5-34.

Full-time S&E graduate students, by source and mechanism of primary support: 1980-95

Support source	All mechanisms	Fellowships	Traineeships	Research assistantships	Teaching assistantships	Other	Self-support
				Number			
Total							
1980	238,492	20,532	17,550	51,567	53,890	19,446	75,507
1981	242,118	20,106	16,777	52,722	55,746	20,210	76,557
1982	244,830	20,873	14,640	52,580	58,334	20,455	77,948
1983	252,092	21,365	13,514	54,904	60,072	20,960	81,277
1984	253,959	21,638	13,465	57,735	61,257	20,697	79,167
1985	257,351	22,576	13,665	60,995	61,822	20,635	77,658
1986	266,197	22,966	13,526	66,011	62,563	22,246	78,885
1987	271,080	21,965	14,096	70,214	62,859	22,166	79,780
1988	275,204	22,361	14,397	74,588	63,071	21,584	79,203
1989	282,741	23,476	14,527	79,059	64,316	21,082	80,281
1990	292,854	25,269	15,212	80,747	64,973	22,265	84,388
1991	307,049	26,697	15,417	85,175	65,229	22,956	91,575
1992	322,753	28,666	15,376	88,032	65,739	23,565	101,375
1993	329,876	29,170	15,452	90,158	67,344	21,378	106,374
1994	332,453	28,976	15,716	92,033	66,900	21,672	107,156
1995	330,235	28,954	16,108	89,983	66,147	22,294	106,749
			Federal				
1980	52,969	4,635	13,306	29,316	662	5,050	NA
1981	50,903	4,093	12,176	29,147	619	4,868	NA
1982	47,411	4,097	10,077	28,313	428	4,496	NA
1983	47,764	4,118	9,114	29,152	498	4,882	NA
1984	47,793	4,125	8,970	29,463	400	4,835	NA
1985	49,058	4,423	8,954	30,433	549	4,699	NA
1986	51,365	4,600	8,688	32,739	495	4,843	NA
1987	53,542	4,449	8,922	34,996	444	4,731	NA
1988	55,492	4,569	8,664	36,752	504	5,003	NA
1989	57,444	5,177	8,682	38,555	490	4,540	NA
1990	59,274	6,316	9,242	38,504	609	4,603	NA
1991	63,017	7,447	9,630	40,790	476	4,674	NA
1992	65,634	7,761	10,055	42,588	643	4,587	NA
1993	67,697	7,515	10,188	44,504	846	4,644	NA
1994	68,583	6,945	10,418	45,633	780	4,807	NA
1995	67,469	6,904	10,314	44,503	732	5,016	NA
			Nonfederal				
1980	110,016	15,897	4,244	22,251	53,228	14,396	NA
1981	114,658	16,013	4,601	23,575	55,127	15,342	NA
1982	119,471	16,776	4,563	24,267	57,906	15,959	NA
1983	123,051	17,247	4,400	25,752	59,574	16,078	NA
1984	126,999	17,513	4,495	28,272	60,857	15,862	NA
1985	130,635	18,153	4,711	30,562	61,273	15,936	NA
1986	135,947	18,366	4,838	33,272	62,068	17,403	NA
1987	137,758	17,516	5,174	35,218	62,415	17,435	NA
1988	140,509	17,792	5,733	37,836	62,567	16,581	NA
1989	145,016	18,299	5,845	40,504	63,826	16,542	NA
1990	149,192	18,953	5,970	42,243	64,364	17,662	NA
1991	152,457	19,250	5,787	44,385	64,753	18,282	NA
1992	155,744	20,905	5,321	45,444	65,096	18,978	NA
1993	155,805	21,655	5,264	45,654	66,498	16,734	NA
1994	156,714	22,031	5,298	46,400	66,120	16,865	NA
1995	156,017	22,050	5,794	45,480	65,415	17,278	NA

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Appendix table 5-34.
Full-time S&E graduate students, by source and mechanism of primary support: 1980-95

Support source	All mechanisms	Fellowships	Traineeships	Research assistantships	Teaching assistantships	Other	Self-support
			Percent				
Total							
1980	100.0	8.6	7.4	21.6	22.6	8.2	31.7
1981	100.0	8.3	6.9	21.8	23.0	8.3	31.6
1982	100.0	8.5	6.0	21.5	23.8	8.4	31.8
1983	100.0	8.5	5.4	21.8	23.8	8.3	32.2
1984	100.0	8.5	5.3	22.7	24.1	8.1	31.2
1985	100.0	8.8	5.3	23.7	24.0	8.0	30.2
1986	100.0	8.6	5.1	24.8	23.5	8.4	29.6
1987	100.0	8.1	5.2	25.9	23.2	8.2	29.4
1988	100.0	8.1	5.2	27.1	22.9	7.8	28.8
1989	100.0	8.3	5.1	28.0	22.7	7.5	28.4
1990	100.0	8.6	5.2	27.6	22.2	7.6	28.8
1991	100.0	8.7	5.0	27.7	21.2	7.5	29.8
1992	100.0	8.9	4.8	27.3	20.4	7.3	31.4
1993	100.0	8.8	4.7	27.3	20.4	6.5	32.2
1994	100.0	8.7	4.7	27.7	20.1	6.5	32.2
1995	100.0	8.8	4.9	27.2	20.0	6.8	32.3
			Federal				
1980	100.0	8.8	25.1	55.3	1.2	9.5	NA
1981	100.0	8.0	23.9	57.3	1.2	9.6	NA
1982	100.0	8.6	21.3	59.7	0.9	9.5	NA
1983	100.0	8.6	19.1	61.0	1.0	10.2	NA
1984	100.0	8.6	18.8	61.6	0.8	10.1	NA
1985	100.0	9.0	18.3	62.0	1.1	9.6	NA
1986	100.0	9.0	16.9	63.7	1.0	9.4	NA
1987	100.0	8.3	16.7	65.4	0.8	8.8	NA
1988	100.0	8.2	15.6	66.2	0.9	9.0	NA
1989	100.0	9.0	15.1	67.1	0.9	7.9	NA
1990	100.0	10.7	15.6	65.0	1.0	7.8	NA
1991	100.0	11.8	15.3	64.7	0.8	7.4	NA
1992	100.0	11.8	15.3	64.9	1.0	7.0	NA
1993	100.0	11.1	15.0	65.7	1.2	6.9	NA
1994	100.0	10.1	15.2	66.5	1.1	7.0	NA
1995	100.0	10.2	15.3	66.0	1.1	7.4	NA
			Nonfederal				
1980	100.0	14.4	3.9	20.2	48.4	13.1	NA
1981	100.0	14.0	4.0	20.6	48.1	13.4	NA
1982	100.0	14.0	3.8	20.3	48.5	13.4	NA
1983	100.0	14.0	3.6	20.9	48.4	13.1	NA
1984	100.0	13.8	3.5	22.3	47.9	12.5	NA
1985	100.0	13.9	3.6	23.4	46.9	12.2	NA
1986	100.0	13.5	3.6	24.5	45.7	12.8	NA
1987	100.0	12.7	3.8	25.6	45.3	12.7	NA
1988	100.0	12.7	4.1	26.9	44.5	11.8	NA
1989	100.0	12.6	4.0	27.9	44.0	11.4	NA
1990	100.0	12.7	4.0	28.3	43.1	11.8	NA
1991	100.0	12.6	3.8	29.1	42.5	12.0	NA
1992	100.0	13.4	3.4	29.2	41.8	12.2	NA
1993	100.0	13.9	3.4	29.3	42.7	10.7	NA
1994	100.0	14.1	3.4	29.6	42.2	10.8	NA
1995	100.0	14.1	3.7	29.2	41.9	11.1	NA

NA = not available.

NOTE: Science and engineering includes the health fields (medical sciences and other life sciences).

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Graduate Students and Postdoctorates in Science and Engineering, various years, unpublished tabulations.

See figures 5-17 and 5-18.

Appendix table 5-35.
Full-time S&E graduate students, by institution type, and source and mechanism of primary support: 1995

	Source of support			
Institution type & support mechanism	Total	Federal	Nonfederal	Self
	Number of full-time S&E graduate students			
Private, all mechanisms	96,997	19,978	39,557	37,462
Fellowship	13,247	2,849	10,398	NA
Traineeship	7,276	3,870	3,406	NA
Research assistantship	20,070	11,939	8,131	NA
Teaching assistantship	12,293	209	12,084	NA
Other	44,111	1,111	5,538	37,462
Public, all mechanisms	233,238	47,491	116,460	69,287
Fellowship	15,707	4,055	11,652	NA
Traineeship	8,832	6,444	2,388	NA
Research assistantship	69,913	32,564	37,349	NA
Teaching assistantship	53,854	523	53,331	NA
Other	84,932	3,905	11,740	69,287
	Percent of full-time S&E graduate students			
Private, all mechanisms	100.0	100.0	100.0	100.0
Fellowship	13.7	14.3	26.3	NA
Traineeship	7.5	19.4	8.6	NA
Research assistantship	20.7	59.8	20.6	NA
Teaching assistantship	12.7	1.0	30.5	NA
Other	45.5	5.6	14.0	100.0
Public, all mechanisms	100.0	100.0	100.0	100.0
Fellowship	6.7	8.5	10.0	NA
Traineeship	3.8	13.6	2.1	NA
Research assistantship	30.0	68.6	32.1	NA
Teaching assistantship	23.1	1.1	45.8	NA
Other	36.4	8.2	10.1	100.0
	Percent of full-time S&E graduate students			
Private, all mechanisms	100.0	20.6	40.8	38.6
Fellowship	100.0	21.5	78.5	NA
Traineeship	100.0	53.2	46.8	NA
Research assistantship	100.0	59.5	40.5	NA
Teaching assistantship	100.0	1.7	98.3	NA
Other	100.0	2.5	12.6	84.9
Public, all mechanisms	100.0	20.4	49.9	29.7
Fellowship	100.0	25.8	74.2	NA
Traineeship	100.0	73.0	27.0	NA
Research assistantship	100.0	46.6	53.4	NA
Teaching assistantship	100.0	1.0	99.0	NA
Other	100.0	4.6	13.8	81.6

NA = not available

NOTE: Science and engineering includes the health sciences (medical sciences and other life sciences).

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Graduate Students and Postdoctorates in Science and Engineering, various years, unpublished tabulations.

Science & Engineering Indicators – 1998

Appendix table 5-36.
Primary mechanisms of support for 1995 S&E Ph.D. recipients, by degree field

Field	All mechanisms	Research assistantships	Fellowships	Traineeships	Teaching assistantships	Other	Self-support
Number							
TOTAL S&E	27,846	8,058	666	3,744	1,795	8,592	4,991
Total sciences	21,839	5,497	525	3,296	1,654	6,603	4,264
Physical sciences	3,840	1,679	91	661	112	1,052	245
Astronomy	173	91	6	20	5	45	6
Chemistry	2,161	826	46	428	72	638	151
Physics	1,479	749	38	212	34	358	88
Other	27	13	1	1	1	11	0
Mathematics	1,190	132	27	566	39	323	103
Computer sciences	998	317	26	152	28	279	196
Environmental sciences	778	314	15	77	24	239	109
Atmospheric sciences	130	72	0	3	2	43	10
Earth sciences	454	170	11	65	13	134	61
Oceanography	114	56	1	4	4	39	10
Other	80	16	3	5	5	23	28
Life sciences	7,737	2,247	213	691	950	2,391	1,245
Agricultural sciences	1,036	407	28	33	23	406	139
Biological sciences	5,370	1,673	171	566	830	1,519	611
Medical sciences	556	104	12	40	52	190	158
Other	775	63	2	52	45	276	337
Psychology	3,419	395	42	368	175	1,072	1,367
Social sciences	3,877	413	111	781	326	1,247	999
Anthropology	410	22	16	68	40	133	131
Economics	1,153	170	34	274	97	394	184
History of science	41	3	3	11	3	11	10
Linguistics	201	11	4	61	17	55	53
Political science	893	71	20	152	75	289	286
Sociology	554	76	17	103	48	167	143
Other	625	60	17	112	46	198	192
Total engineering	6,007	2,561	141	448	141	1,989	727
Aeronautical/ astronautical	251	105	5	25	7	90	19
Chemical	708	336	23	44	27	227	51
Civil	656	238	8	34	11	264	101
Electrical/electronics	1,731	703	50	143	36	562	237
Industrial	283	64	6	40	11	93	69
Mechanical	1,024	452	11	103	15	325	118
Materials	588	341	11	19	9	167	41
Other	766	322	27	40	25	261	91

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Appendix table 5-36.

Primary mechanisms of support for 1995 S&E Ph.D. recipients, by degree field

Field	All mechanisms	Research assistantships	Fellowships	Traineeships	Teaching assistantships	Other	Self-support
			Percent				
TOTAL S&E	100.0	28.9	2.4	13.4	6.4	30.9	17.9
Total sciences	100.0	25.2	2.4	15.1	7.6	30.2	19.5
Physical sciences	100.0	43.7	2.4	17.2	2.9	27.4	6.4
Astronomy	100.0	52.6	3.5	11.6	2.9	26.0	3.5
Chemistry	100.0	38.2	2.1	19.8	3.3	29.5	7.0
Physics	100.0	50.6	2.6	14.3	2.3	24.2	5.9
Other	100.0	48.1	3.7	3.7	3.7	40.7	0.0
Mathematics	100.0	11.1	2.3	47.6	3.3	27.1	8.7
Computer sciences	100.0	31.8	2.6	15.2	2.8	28.0	19.6
Environmental sciences	100.0	40.4	1.9	9.9	3.1	30.7	14.0
Atmospheric sciences	100.0	55.4	0.0	2.3	1.5	33.1	7.7
Earth sciences	100.0	37.4	2.4	14.3	2.9	29.5	13.4
Oceanography	100.0	49.1	0.9	3.5	3.5	34.2	8.8
Other	100.0	[illegible]	3.8	6.3	6.3	28.8	35.0
Life sciences	100.0	[illegible]	2.8	8.9	12.3	30.9	16.1
Agricultural sciences	100.0	39.1	2.7	3.2	2.2	39.2	13.4
Biological sciences	100.0	31.2	3.2	10.5	15.5	28.3	11.4
Medical sciences	100.0	18.7	2.2	7.2	9.4	34.2	28.4
Other	100.0	[illegible]	0.3	6.7	5.8	35.6	43.5
Psychology	100.0	11.6	1.2	10.8	5.1	31.4	40.0
Social sciences	100.0	10.7	2.9	20.1	8.4	32.2	25.8
Anthropology	100.0	5.4	3.9	16.6	9.8	32.4	32.0
Economics	100.0	14.7	2.9	23.8	8.4	34.2	16.0
History of science	100.0	7.3	7.3	26.8	7.3	26.8	24.4
Linguistics	100.0	5.5	2.0	30.3	8.5	27.4	26.4
Political science	100.0	8.0	2.2	17.0	8.4	32.4	32.0
Sociology	100.0	13.7	3.1	18.6	8.7	30.1	25.8
Other	100.0	9.6	2.7	17.9	7.4	31.7	30.7
Total engineering	100.0	42.6	2.3	7.5	2.3	33.1	12.1
Aeronautical/ astronautical	100.0	41.8	2.0	10.0	2.8	35.9	7.6
Chemical	100.0	47.5	3.2	6.2	3.8	32.1	7.2
Civil	100.0	36.3	1.2	5.2	1.7	40.2	15.4
Electrical/electronics	100.0	40.6	2.9	8.3	2.1	32.5	13.7
Industrial	100.0	22.6	2.1	14.1	3.9	32.9	24.4
Mechanical	100.0	44.1	1.1	10.1	1.5	31.7	11.5
Materials	100.0	58.0	1.9	3.2	1.5	28.4	7.0
Other	100.0	42.0	3.5	5.2	3.3	34.1	11.9

NA = not available

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Earned Doctorates, various years, unpublished tabulations.

See figure 5-20.

Appendix table 5-37.

Full-time S&E graduate students, by field and mechanism of primary support: 1995

Field	All mechanisms	Research assistantships	Fellowships	Traineeships	Teaching assistantships	Other	Self-support
			Number				
TOTAL S&E	330,235	89,983	28,954	16,108	66,147	22,294	106,749
Total sciences	262,373	62,958	22,921	15,099	55,931	17,289	88,175
Physical sciences	28,892	11,808	2,354	688	11,710	730	1,602
Astronomy	871	439	148	28	225	5	26
Chemistry	16,750	6,466	1,270	445	7,386	372	811
Physics	11,054	4,842	929	215	4,073	349	646
Other	217	61	7	0	26	4	119
Mathematics	13,422	1,451	1,274	222	7,316	675	2,484
Computer sciences	16,564	3,921	924	216	3,364	1,551	6,588
Environmental sciences	11,290	4,661	891	136	2,507	730	2,365
Atmospheric sciences	959	619	67	8	107	69	89
Earth sciences	5,810	2,151	512	59	1,855	334	899
Oceanography	2,228	1,257	195	24	215	166	371
Other	2,293	634	117	45	330	161	1,006
Life sciences	100,132	29,158	8,104	10,942	13,089	6,587	32,252
Agricultural sciences	9,630	5,401	454	146	941	477	2,211
Biological sciences	48,283	19,182	5,395	5,308	9,293	2,143	6,962
Medical sciences	13,863	2,928	1,272	1,661	1,246	1,292	5,464
Other	28,356	1,647	983	3,827	1,609	2,675	17,615
Psychology	35,762	4,626	1,824	1,115	6,152	3,094	18,951
Social sciences	56,311	7,333	7,550	1,780	11,793	3,922	23,933
Anthropology	5,792	452	1,168	132	1,278	344	2,418
Economics	11,746	2,094	1,546	271	3,028	809	3,998
History of science	340	17	127	10	99	18	69
Linguistics	2,486	177	369	50	701	282	907
Political science	17,660	1,624	2,468	777	2,666	1,136	8,989
Sociology	7,353	1,131	915	241	2,145	431	2,490
Other	10,934	1,838	957	299	1,876	902	5,062
Total engineering	67,862	27,025	6,033	1,009	10,216	5,005	18,574
Aeronautical/ astronautical	2,693	1,175	262	31	315	377	533
Chemical	5,962	3,100	791	105	907	218	841
Civil	12,248	4,225	924	196	1,850	816	4,237
Electrical/electronics	18,303	6,684	1,455	156	3,137	1,439	5,432
Industrial	5,328	1,339	300	37	824	504	2,324
Mechanical	11,119	4,419	942	187	1,950	777	2,844
Materials	3,880	2,535	371	48	352	123	451
Other	8,329	3,548	988	249	881	751	1,912

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Appendix table 5-37.

Full-time S&E graduate students, by field and mechanism of primary support: 1995

Field	All mechanisms	Research assistantships	Fellowships	Traineeships	Teaching assistantships	Other	Self-support
			Percent				
TOTAL S&E	100.0	27.2	8.8	4.9	20.0	6.8	32.3
Total sciences	100.0	24.0	8.7	5.8	21.3	6.6	33.6
Physical sciences	100.0	40.9	8.1	2.4	40.5	2.5	5.5
Astronomy	100.0	50.4	17.0	3.2	25.8	0.6	3.0
Chemistry	100.0	38.6	7.6	2.7	44.1	2.2	4.8
Physics	100.0	43.8	8.4	1.9	36.8	3.2	5.8
Other	100.0	28.1	3.2	0.0	12.0	1.8	54.8
Mathematics	100.0	10.8	9.5	1.7	54.5	5.0	18.5
Computer sciences	100.0	23.7	5.6	1.3	20.3	9.4	39.8
Environmental sciences	100.0	41.3	7.9	1.2	22.2	6.5	20.9
Atmospheric sciences	100.0	64.5	7.0	0.8	11.2	7.2	9.3
Earth sciences	100.0	37.0	8.8	1.0	31.9	5.7	15.5
Oceanography	100.0	56.4	8.8	1.1	9.6	7.5	16.7
Other	100.0	27.6	5.1	2.0	14.4	7.0	43.9
Life sciences	100.0	29.1	8.1	10.9	13.1	6.6	32.2
Agricultural sciences	100.0	56.1	4.7	1.5	9.8	5.0	23.0
Biological sciences	100.0	39.7	11.2	11.0	19.2	4.4	14.4
Medical sciences	100.0	21.1	9.2	12.0	9.0	9.3	39.4
Other	100.0	5.8	3.5	13.5	5.7	9.4	62.1
Psychology	100.0	12.9	5.1	3.1	17.2	8.7	53.0
Social sciences	100.0	13.0	13.4	3.2	20.9	7.0	42.5
Anthropology	100.0	7.8	20.2	2.3	22.1	5.9	41.7
Economics	100.0	17.8	13.2	2.3	25.8	6.9	34.0
History of science	100.0	5.0	37.4	2.9	29.1	5.3	20.3
Linguistics	100.0	7.1	14.8	2.0	28.2	11.3	36.5
Political science	100.0	9.2	14.0	4.4	15.1	6.4	50.9
Sociology	100.0	15.4	12.4	3.3	29.2	5.9	33.9
Other	100.0	16.8	8.8	2.7	17.2	8.2	46.3
Total engineering	100.0	39.8	8.9	1.5	15.1	7.4	27.4
Aeronautical/ astronautical	100.0	43.6	9.7	1.2	11.7	14.0	19.8
Chemical	100.0	52.0	13.3	1.8	15.2	3.7	14.1
Civil	100.0	34.5	7.5	1.6	15.1	6.7	34.6
Electrical/electronics	100.0	36.5	7.9	0.9	17.1	7.9	29.7
Industrial	100.0	25.1	5.6	0.7	15.5	9.5	43.6
Mechanical	100.0	39.7	8.5	1.7	17.5	7.0	25.6
Materials	100.0	65.3	9.6	1.2	9.1	3.2	11.6
Other	100.0	42.6	11.9	3.0	10.6	9.0	23.0

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Graduate Students and Postdoctorates in Science and Engineering, various years, unpublished tabulations.

See figure 5-20.

Appendix table 5-38.

Full-time S&E graduate students with a research assistantship as mechanism of primary support, by field: 1995

Field	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
					Number of full-time S&E graduate students						
TOTAL S&E	60,995	66,011	70,214	74,588	79,059	80,747	85,175	88,032	90,158	92,033	89,983
Total sciences	43,085	45,593	48,044	51,139	54,466	55,448	58,399	60,492	62,227	63,951	62,958
Physical sciences	10,284	10,992	11,556	12,056	12,442	12,138	12,229	12,445	12,293	12,378	11,808
Astronomy	305	323	336	338	372	383	397	425	395	467	439
Chemistry	5,797	6,173	6,444	6,644	6,803	6,572	6,569	6,606	6,586	6,690	6,466
Physics	4,133	4,447	4,719	5,026	5,235	5,153	5,232	5,359	5,251	5,131	4,842
Other	49	49	57	48	32	30	31	55	61	90	61
Mathematics	998	1,038	1,111	1,226	1,304	1,335	1,356	1,410	1,436	1,534	1,451
Computer sciences	2,058	2,322	2,817	3,032	3,324	3,334	3,565	3,682	3,802	3,903	3,921
Environmental sciences	3,707	3,827	3,647	3,879	4,150	4,189	4,387	4,615	4,729	4,857	4,661
Atmospheric sciences	447	418	441	479	499	493	529	606	626	659	619
Earth sciences	2,126	2,105	1,890	1,973	2,071	2,054	2,061	2,091	2,172	2,215	2,151
Oceanography	848	962	963	1,051	1,166	1,170	1,273	1,339	1,331	1,401	1,257
Other	286	342	353	376	414	472	524	579	600	582	634
Life sciences	17,888	19,220	20,191	21,570	23,162	23,923	25,809	26,755	28,046	29,202	29,158
Agricultural sciences	4,445	4,703	4,603	4,552	4,730	4,755	5,002	5,174	5,239	5,385	5,401
Biological sciences	11,222	12,086	12,944	14,125	15,189	15,764	16,846	17,627	18,853	19,438	19,182
Medical sciences	1,326	1,465	1,675	1,843	2,020	2,188	2,584	2,630	2,582	2,881	2,928
Other	895	966	969	1,050	1,223	1,216	1,377	1,324	1,372	1,498	1,647
Psychology	3,070	3,101	3,227	3,715	3,846	4,052	4,235	4,306	4,559	4,676	4,626
Social sciences	5,080	5,093	5,495	5,661	6,238	6,477	6,818	7,279	7,362	7,401	7,333
Anthropology	277	287	346	353	407	449	462	454	452	454	452
Economics	1,955	2,003	1,994	2,064	2,004	2,055	2,150	2,165	2,214	2,173	2,094
History of science	11	19	18	23	14	14	34	24	7	22	17
Linguistics	163	126	190	179	202	218	178	169	196	197	177
Political science	1,028	1,015	1,116	1,197	1,378	1,375	1,527	1,757	1,637	1,671	1,624
Sociology	765	767	866	860	955	1,117	1,073	1,109	1,202	1,160	1,131
Other	881	876	965	985	1,278	1,249	1,394	1,601	1,654	1,724	1,838
Total engineering	17,910	20,418	22,170	23,449	24,593	25,299	26,776	27,540	27,931	28,082	27,025
Aeronautical/astronautical	725	823	815	934	1,040	1,137	1,232	1,222	1,266	1,245	1,175
Chemical	2,454	2,582	2,745	2,814	2,813	2,839	2,987	3,012	3,120	3,270	3,100
Civil	2,417	2,786	2,900	3,072	3,042	3,115	3,565	3,936	4,048	4,254	4,225
Electrical/electronic	3,695	4,474	5,132	5,735	6,141	6,224	6,556	6,867	6,925	6,855	6,684
Industrial	572	705	923	1,030	1,141	1,130	1,249	1,235	1,271	1,342	1,339
Mechanical	3,280	3,666	3,947	4,069	4,248	4,306	4,630	4,731	4,787	4,688	4,419
Materials	1,963	2,247	2,264	2,333	2,512	2,547	2,507	2,661	2,651	2,608	2,535
Other	2,804	3,135	3,444	3,462	3,656	4,001	4,050	3,876	3,863	3,820	3,548

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Appendix table 5-38.

Full-time S&E graduate students with a research assistantship as mechanism of primary support, by field: 1995

Field	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
	Percent of full-time S&E graduate students										
TOTAL S&E	23.7	24.8	25.9	27.1	28.0	27.6	27.7	27.3	27.3	27.7	27.2
Total sciences	21.4	22.1	23.0	24.1	24.9	24.4	24.7	24.4	24.3	24.5	24.0
Physical sciences	38.6	39.6	40.7	42.2	42.6	41.2	40.6	40.6	40.2	41.2	40.9
Astronomy	48.0	49.4	49.5	47.9	48.8	48.5	49.0	50.6	46.6	49.0	50.4
Chemistry	37.2	38.6	39.7	41.3	41.8	40.1	39.3	38.9	38.3	39.1	38.6
Physics	40.2	40.6	41.7	43.2	43.5	42.3	42.1	42.2	42.4	43.6	43.8
Other	30.2	32.0	29.4	33.6	25.2	24.6	23.1	37.9	37.7	40.9	28.1
Mathematics	8.4	8.4	8.5	9.1	9.5	9.6	9.5	9.6	9.9	10.8	10.8
Computer sciences	14.8	15.5	18.4	20.0	21.3	20.0	21.6	21.0	21.9	23.4	23.7
Environmental sciences	32.7	34.0	34.9	38.1	41.4	40.9	42.3	42.0	41.6	42.3	41.3
Atmospheric sciences	51.3	48.9	53.5	57.8	61.6	59.5	61.6	63.2	63.9	66.4	64.5
Earth sciences	27.6	28.5	28.4	31.3	34.6	35.4	36.2	35.5	36.4	37.3	37.0
Oceanography	54.3	56.8	58.3	64.5	64.8	60.5	63.9	62.8	61.1	60.1	56.4
Other	23.9	26.0	27.3	26.4	29.0	28.0	28.6	28.8	26.8	26.5	27.6
Life sciences	25.7	27.3	28.4	29.6	30.8	30.9	31.5	31.1	30.6	30.2	29.1
Agricultural sciences	48.1	50.3	50.6	49.9	52.1	52.3	53.8	54.7	55.3	56.7	56.1
Biological sciences	30.3	32.0	33.9	36.0	37.6	38.5	39.5	39.7	40.6	40.5	39.7
Medical sciences	15.5	16.8	18.4	19.2	20.2	20.7	23.5	22.4	20.4	21.9	21.1
Other	6.1	6.6	6.6	7.0	7.7	7.2	7.3	6.5	6.0	5.8	5.8
Psychology	12.1	11.8	11.8	13.2	13.1	13.2	13.1	12.6	13.1	13.2	12.9
Social sciences	11.8	11.9	12.6	12.9	13.8	13.4	13.5	13.4	13.2	13.1	13.0
Anthropology	7.1	7.1	8.4	8.3	9.2	9.3	9.1	8.5	8.3	7.8	7.8
Economics	17.9	18.3	18.4	18.9	18.2	18.3	18.1	17.6	18.3	18.2	17.8
History of science	4.8	8.0	6.7	8.6	5.1	4.5	11.2	7.3	2.1	6.5	5.0
Linguistics	7.0	5.3	7.8	7.1	8.2	8.4	7.0	6.8	7.7	7.8	7.1
Political science	7.9	7.6	8.6	9.1	9.8	9.0	9.5	9.9	8.9	9.3	9.2
Sociology	14.7	14.8	15.5	15.2	16.2	17.3	16.3	15.6	16.5	15.6	15.4
Other	12.2	13.0	13.2	14.2	17.7	16.1	17.0	17.7	17.2	16.6	16.8
Total engineering	32.0	33.9	35.8	37.2	38.2	38.3	37.7	37.0	37.8	39.2	39.8
Aeronautical/astronautical	36.4	38.2	34.4	36.9	37.5	37.8	37.1	37.0	38.8	41.5	43.6
Chemical	44.2	46.2	48.4	52.5	53.3	52.2	51.6	50.7	51.6	53.6	52.0
Civil	24.8	27.9	30.1	30.9	30.5	30.8	31.5	31.6	32.5	33.7	34.5
Electrical/electronic	25.0	27.5	30.0	32.4	33.3	33.3	32.9	32.7	33.9	35.3	36.5
Industrial	16.6	18.5	22.2	24.0	24.5	23.7	22.3	20.3	21.5	22.7	25.1
Mechanical	37.0	37.5	38.6	39.1	40.5	39.6	39.6	38.2	38.6	39.5	39.7
Materials	63.5	66.7	65.9	67.3	67.5	64.8	61.8	62.3	62.4	63.5	65.3
Other	33.4	34.1	36.9	37.3	40.5	43.7	43.3	43.1	42.4	44.9	42.6

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Graduate Students and Postdoctorates in Science and Engineering, various years, unpublished tabulations.

See figure 5-19.

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Science & Engineering Indicators – 1998

Appendix table 5-39.

S&E research assistants, by field and primary source of support: 1995

Field	Total number	Total percent	Number of research assistants		Percent of research assistants	
			Federal	Nonfederal	Federal	Nonfederal
TOTAL SCIENCE & ENGINEERING	89,983	100.0	44,503	45,480	49.5	50.5
Total sciences	62,958	70.0	31,868	31,090	50.6	49.4
Physical sciences	11,808	13.1	8,852	2,956	75.0	25.0
Astronomy	439	0.5	335	104	76.3	23.7
Chemistry	6,466	7.2	4,721	1,745	73.0	27.0
Physics	4,842	5.4	3,764	1,078	77.7	22.3
Other	61	0.1	32	29	52.5	47.5
Mathematics	1,451	1.6	659	792	45.4	54.6
Computer sciences	3,921	4.4	2,429	1,492	61.9	38.1
Environmental sciences	4,661	5.2	2,935	1,726	63.0	37.0
Atmospheric sciences	619	0.7	507	112	81.9	18.1
Earth sciences	2,151	2.4	1,339	812	62.3	37.7
Oceanography	1,257	1.4	848	409	67.5	32.5
Other	634	0.7	241	393	38.0	62.0
Life sciences	29,158	32.4	14,036	15,122	48.1	51.9
Agricultural sciences	5,401	6.0	1,863	3,538	34.5	65.5
Biological sciences	19,182	21.3	10,513	8,669	54.8	45.2
Medical sciences	2,928	3.3	1,165	1,763	39.8	60.2
Other	1,647	1.8	495	1,152	30.1	69.9
Psychology	4,626	5.1	1,481	3,145	32.0	68.0
Social sciences	7,333	8.1	1,476	5,857	20.1	79.9
Anthropology	452	0.5	102	350	22.6	77.4
Economics	2,094	2.3	533	1,561	25.5	74.5
History of science	17	0.0	1	16	5.9	94.1
Linguistics	177	0.2	58	119	32.8	67.2
Political science	1,624	1.8	115	1,509	7.1	92.9
Sociology	1,131	1.3	237	894	21.0	79.0
Other	1,838	2.0	430	1,408	23.4	76.6
Total engineering	27,025	30.0	12,635	14,390	46.8	53.2
Aeronautical/astronautical	1,175	1.3	668	507	56.9	43.1
Chemical	3,100	3.4	1,400	1,700	45.2	54.8
Civil	4,225	4.7	1,581	2,644	37.4	62.6
Electrical/electronics	6,684	7.4	3,316	3,368	49.6	50.4
Industrial	1,339	1.5	408	931	30.5	69.5
Mechanical	4,419	4.9	2,201	2,218	49.8	50.2
Materials	2,535	2.8	1,374	1,161	54.2	45.8
Other	3,548	3.9	1,687	1,861	47.5	52.5

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Graduate Students and Postdoctorates in Science and Engineering, various years, unpublished tabulations.

Science & Engineering Indicators – 1998

Appendix table 5-40.

S&E research assistants whose primary source of support is the Federal Government, by field: 1975-95

(Percentages)

Field	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
TOTAL S&E	57.6	57.2	57.4	NA	57.2	56.9	55.3	53.8	53.1	51.0	49.9	49.6	49.8	49.3	48.8	47.7	47.9	48.4	49.4	49.6	49.5
Total sciences	55.5	54.8	55.2	NA	55.3	55.2	53.8	52.0	51.2	50.2	51.1	50.8	51.2	50.5	50.2	49.3	49.5	50.1	51.1	51.0	50.6
Physical sciences	85.2	83.8	84.7	NA	83.4	83.7	84.5	80.9	81.7	81.1	78.4	78.8	76.8	74.4	73.6	72.9	72.8	73.0	74.7	76.1	75.0
Astronomy	84.5	87.7	84.0	NA	82.0	87.4	87.1	80.8	86.7	82.1	86.2	88.9	75.3	79.0	77.4	70.2	72.5	79.1	83.5	80.5	76.3
Chemistry	82.4	80.3	80.2	NA	79.9	81.7	80.9	80.2	77.4	77.3	75.3	76.2	73.4	71.8	69.8	70.6	69.1	69.8	71.6	73.8	73.0
Physics	89.0	87.9	90.5	NA	88.1	86.0	89.5	82.5	87.9	86.5	82.7	82.2	81.7	77.8	78.5	76.1	77.5	76.4	78.1	78.8	77.7
Other	25.8	30.0	73.7	NA	56.3	100.0	13.3	12.9	39.5	52.8	36.7	42.9	52.6	41.7	50.0	50.0	48.4	72.7	70.5	74.4	52.5
Mathematics	47.7	51.3	51.4	NA	51.4	53.7	44.7	44.6	43.6	47.1	47.9	51.8	57.2	54.3	50.8	45.7	47.5	48.5	51.3	48.4	45.4
Computer sci.	60.6	52.8	65.5	NA	71.1	65.4	65.1	64.1	60.2	60.1	52.0	49.3	53.2	54.2	53.5	53.5	54.8	54.2	58.5	61.0	61.9
Environmental sci.	73.7	71.5	71.6	NA	75.6	71.8	69.3	69.6	66.4	65.2	64.8	61.9	61.5	59.6	59.7	59.0	58.4	62.5	63.4	63.3	63.0
Atmospheric sci.	79.7	90.7	93.7	NA	95.3	91.0	89.0	89.2	83.4	81.4	87.7	86.6	86.8	78.9	89.0	93.5	86.0	89.6	87.4	86.8	81.9
Earth sciences	74.3	69.1	71.2	NA	74.0	71.8	65.8	66.3	63.7	62.4	60.3	58.4	58.5	57.5	59.4	57.8	57.4	60.6	61.6	60.9	62.3
Oceanography	73.3	69.7	68.3	NA	74.8	72.0	69.9	69.6	70.4	70.5	71.7	66.6	65.9	60.5	55.1	57.4	56.9	62.7	65.0	65.0	67.5
Other	60.9	61.6	52.4	NA	60.7	49.2	61.2	59.4	49.5	46.0	42.0	39.8	33.7	43.9	39.4	32.2	38.0	40.6	41.0	41.9	38.0
Life sciences	47.5	48.0	47.2	NA	46.9	48.0	46.5	45.0	44.1	42.1	44.7	44.6	46.4	46.7	47.3	46.8	47.2	47.9	48.5	48.3	48.1
Agricultural sci.	35.7	34.1	34.8	NA	32.9	34.8	32.0	31.5	28.9	25.1	29.6	29.5	31.3	32.3	32.8	32.2	33.3	34.2	33.4	32.3	34.5
Biological sci.	52.8	54.6	53.0	NA	54.2	55.6	54.1	52.5	52.2	50.9	52.3	52.2	53.1	53.1	54.1	53.5	53.8	54.1	55.0	54.7	54.8
Medical sci.	60.0	57.4	53.9	NA	47.8	46.3	44.9	42.8	42.5	37.2	40.1	38.6	43.5	42.1	41.6	38.8	38.8	41.4	42.4	43.2	39.8
Other	53.4	45.3	49.0	NA	35.6	31.0	34.9	29.3	27.8	28.7	30.9	31.5	33.8	31.6	28.0	32.2	31.6	31.9	27.6	32.2	30.1
Psychology	45.5	43.2	44.9	NA	46.3	36.7	35.9	34.0	31.9	31.8	33.1	32.9	33.4	32.5	33.1	32.7	33.9	33.4	34.0	31.7	32.0
Social sciences	29.1	27.6	28.5	NA	26.9	27.3	24.4	19.9	18.5	17.7	19.1	17.4	16.7	16.6	16.6	17.0	18.1	19.1	20.2	19.4	20.1
Anthropology	41.3	34.8	29.1	NA	34.8	30.1	40.6	28.6	24.8	15.8	22.4	16.7	19.7	19.5	15.7	12.2	13.4	20.7	23.0	19.6	22.6
Economics	29.5	25.7	30.5	NA	28.7	30.8	25.9	23.2	22.7	21.5	23.7	22.6	22.5	21.7	23.1	21.6	21.0	22.1	24.4	24.9	25.5
History of sci.	0.0	30.0	41.7	NA	18.2	7.1	0.0	0.0	0.0	0.0	9.1	0.0	5.6	13.0	7.1	21.4	20.6	12.5	42.9	18.2	5.9
Linguistics	38.8	56.3	43.3	NA	31.7	31.7	27.6	23.6	27.7	24.4	22.7	31.7	16.8	10.1	19.3	14.7	23.6	28.4	28.6	32.5	32.8
Political science	10.3	11.8	12.5	NA	11.2	10.1	4.6	6.0	4.9	6.6	6.1	4.4	3.1	5.4	6.0	6.8	9.8	5.6	8.7	6.8	7.1
Sociology	35.1	34.3	35.0	NA	35.7	39.4	36.9	25.8	23.5	21.7	28.4	23.5	19.2	19.7	18.3	19.4	21.3	22.5	21.5	19.1	21.0
Other	33.1	32.3	27.6	NA	26.9	23.7	23.1	19.2	18.4	20.7	14.3	13.6	17.2	17.4	16.4	20.4	20.9	26.3	23.2	23.4	23.4
Total engineering	63.1	63.7	63.4	NA	62.4	61.3	59.3	58.6	57.9	53.2	47.1	46.8	46.8	46.6	45.6	44.2	44.4	44.7	45.6	46.2	46.8
Aero./astronautical	75.2	68.2	73.6	NA	70.6	64.7	68.4	76.0	78.3	77.9	65.9	67.8	69.6	67.9	59.9	57.3	60.1	58.0	57.4	57.8	56.9
Chemical	61.9	61.2	61.6	NA	55.9	57.2	54.1	51.6	52.0	49.2	44.9	47.3	48.2	46.0	44.5	44.9	43.1	43.3	44.6	43.0	45.2
Civil	52.5	54.8	52.4	NA	56.8	58.3	50.9	52.2	47.1	45.5	41.7	40.1	42.1	39.7	39.4	37.9	39.5	40.0	39.0	39.0	37.4
Electrical/electronic	77.7	77.3	75.1	NA	72.3	69.5	68.2	69.9	66.4	57.6	46.0	45.4	45.6	47.3	44.0	42.9	43.7	43.8	44.3	46.7	49.6
Industrial	42.6	36.1	46.1	NA	40.9	44.2	44.6	34.5	39.5	30.3	26.9	24.8	26.8	28.1	25.2	23.8	29.9	27.4	28.2	31.1	30.5
Mechanical	63.9	66.6	67.5	NA	64.7	60.4	60.0	57.7	60.0	55.2	48.3	46.6	48.8	50.7	50.3	47.7	45.8	46.6	50.3	51.3	49.8
Materials	71.0	74.5	72.7	NA	76.7	73.2	72.7	70.1	67.8	63.5	58.4	58.9	54.8	55.2	56.2	52.1	50.6	52.8	52.5	52.6	54.2
Other	54.7	56.1	54.6	NA	53.8	54.9	52.5	51.6	51.5	48.5	44.9	45.4	44.0	41.4	43.8	43.5	45.0	45.2	46.6	47.4	47.5

NA = not available

NOTE: Science and engineering includes the health sciences (medical sciences and other life sciences).

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Graduate Students and Postdoctorates in Science and Engineering, various years, unpublished tabulations.

See figure 5-21.

Appendix table 5-41.

Federal research assistantships, by agency of primary support: 1972-95

	All federal agencies	National Institutes of Health	Other Department of Health & Human Services	National Science Foundation	Department of Defense	Department of Agriculture[a]	All other agencies
			Number				
1972	20,666	3,395	513	6,832	2,676	NA	7,250
1973	20,584	2,953	793	6,901	2,371	NA	7,566
1974	22,255	3,468	906	6,899	2,657	NA	8,325
1975	23,037	3,884	866	6,819	2,494	NA	8,974
1976	24,338	4,450	882	7,031	2,537	NA	9,438
1977	25,066	4,304	931	7,037	2,637	NA	10,157
1978	NA	NA	NA	NA	NA	NA	NA
1979	28,008	5,060	1,100	7,501	2,801	NA	11,546
1980	29,316	5,436	587	7,627	2,934	NA	12,732
1981	29,147	5,505	543	7,596	3,297	NA	12,206
1982	28,313	5,295	509	7,747	3,467	NA	11,295
1983	29,152	5,456	549	8,066	3,934	NA	11,147
1984	29,463	5,762	583	8,283	4,081	NA	10,754
1985	30,433	6,147	751	8,558	4,195	1,818	8,964
1986	32,739	7,001	710	9,084	4,646	1,954	9,344
1987	34,996	7,662	814	9,487	5,617	2,325	9,091
1988	36,752	8,598	761	9,822	6,028	2,300	9,243
1989	38,555	9,342	906	9,875	5,916	2,448	10,068
1990	38,504	9,463	965	9,705	5,412	2,431	10,528
1991	40,790	9,990	1,055	10,161	5,484	2,816	11,284
1992	42,588	10,623	986	10,652	5,727	2,959	11,641
1993	44,504	11,368	725	10,814	6,232	3,019	12,346
1994	45,633	11,624	902	11,194	6,217	3,143	12,553
1995	44,503	11,382	990	10,672	6,337	2,997	12,125
			Percent				
1972	100.0	16.4	2.5	33.1	12.9	NA	35.1
1973	100.0	14.3	3.9	33.5	11.5	NA	36.8
1974	100.0	15.6	4.1	31.0	11.9	NA	37.4
1975	100.0	16.9	3.8	29.6	10.8	NA	39.0
1976	100.0	18.3	3.6	28.9	10.4	NA	38.8
1977	100.0	17.2	3.7	28.1	10.5	NA	40.5
1978	NA	NA	NA	NA	NA	NA	NA
1979	100.0	18.1	3.9	26.8	10.0	NA	41.2
1980	100.0	18.5	2.0	26.0	10.0	NA	43.4
1981	100.0	18.9	1.9	26.1	11.3	NA	41.9
1982	100.0	18.7	1.8	27.4	12.2	NA	39.9
1983	100.0	18.7	1.9	27.7	13.5	NA	38.2
1984	100.0	19.6	2.0	28.1	13.9	NA	36.5
1985	100.0	20.2	2.5	28.1	13.8	6.0	29.5
1986	100.0	21.4	2.2	27.7	14.2	6.0	28.5
1988	100.0	23.4	2.1	26.7	16.4	6.3	25.1
1989	100.0	24.2	2.3	25.6	15.3	6.3	26.1
1990	100.0	24.6	2.5	25.2	14.1	6.3	27.3
1991	100.0	24.5	2.6	24.9	13.4	6.9	27.7
1992	100.0	24.9	2.3	25.0	13.4	6.9	27.3
1993	100.0	25.5	1.6	24.3	14.0	6.8	27.7
1994	100.0	25.5	2.0	24.5	13.6	6.9	27.5
1995	100.0	25.6	2.2	24.0	14.2	6.7	27.2

NA = not available

NOTE: Percentages may not total 100 because of rounding.

[a] Data were reported for the Department of Agriculture for the first time in 1985.

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Graduate Students and Postdoctorates in Science and Engineering, various years, unpublished tabulations.

Appendix table 5-42.
S&E research assistants with primary support from federal agencies, by field: 1995
(Percentages)

Field	All federal agencies	National Science Foundation	Department of Defense	National Institutes of Health	Other Department of Health & Human Services	Department of Agriculture	All other agencies
TOTAL S&E	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total sciences	71.6	65.6	44.8	95.3	88.9	89.8	62.7
Physical sciences	19.9	30.2	15.6	14.3	13.7	1.2	23.4
Astronomy	0.8	1.2	0.1	0.0	0.0	0.0	1.7
Chemistry	10.6	15.8	6.9	13.6	12.5	1.0	7.4
Physics	8.5	13.3	8.6	0.6	1.2	0.2	14.1
Other	0.1	0.0	0.0	0.1	0.0	0.0	0.1
Mathematics	1.5	2.7	2.0	0.4	1.8	0.4	1.4
Computer sciences	5.5	8.4	16.3	0.7	1.1	0.4	3.3
Environmental sciences	6.6	11.6	4.3	0.2	0.3	1.9	11.1
Atmospheric sciences	1.1	1.8	0.7	0.0	0.2	0.3	2.1
Earth sciences	3.0	6.7	0.4	0.0	0.0	0.5	4.7
Oceanography	1.9	2.7	2.7	0.1	0.0	0.1	3.1
Other	0.5	0.3	0.4	0.1	0.1	1.0	1.1
Life sciences	31.5	9.2	3.9	71.6	52.8	72.2	16.3
Agricultural sciences	4.2	0.7	0.4	0.1	0.5	37.6	5.1
Biological sciences	23.6	7.9	2.8	62.2	32.9	32.9	9.1
Medical sciences	2.6	0.4	0.6	7.1	8.8	1.6	1.2
Other	1.1	0.2	0.1	2.2	10.6	0.0	0.9
Psychology	3.3	1.2	1.8	7.0	14.4	0.5	2.4
Social sciences	3.3	2.2	0.9	1.2	4.6	13.1	4.9
Anthropology	0.2	0.2	0.1	0.1	0.0	0.0	0.5
Economics	1.2	0.4	0.1	0.1	1.4	10.3	1.3
History of science	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Linguistics	0.1	0.2	0.1	0.1	0.2	0.0	0.1
Political science	0.3	0.2	0.1	0.0	0.7	0.3	0.6
Sociology	0.5	0.4	0.0	0.7	1.8	1.5	0.5
Other	1.0	0.9	0.6	0.2	0.5	1.0	1.9
Total engineering	28.4	34.4	55.2	4.7	11.1	10.2	37.3
Aeronautical/astronautical	1.5	0.7	4.0	0.0	0.2	0.1	2.7
Chemical	3.1	5.5	2.3	0.6	1.5	1.9	4.2
Civil	3.6	4.2	3.5	0.3	1.0	1.6	6.8
Electrical/electronics	7.5	10.4	21.7	0.7	1.7	1.1	5.8
Industrial	0.9	1.2	1.2	0.1	2.2	0.0	1.4
Mechanical	4.9	5.1	10.1	0.6	0.7	0.1	7.8
Materials	3.1	4.0	6.8	0.1	1.1	0.1	4.1
Other	3.8	3.2	5.7	2.4	2.6	5.2	4.4

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Graduate Students and Postdoctorates in Science and Engineering, various years, unpublished tabulations.

Science & Engineering Indicators – 1998

See figure 5-22.

Appendix table 5-43.

S&E research assistants with primary support from the Federal Government, by field and agency of primary support: 1995

(Percentages)

Field	All federal agencies	National Science Foundation	Department of Defense	National Institutes of Health	Other Department of Health & Human Services	Department of Agriculture	All other agencies
TOTAL S&E	100.0	24.0	14.2	25.6	2.2	6.7	27.2
Total sciences	100.0	22.0	8.9	34.0	2.8	8.4	23.9
Physical sciences	100.0	36.5	11.2	18.4	1.5	0.4	32.0
Astronomy	100.0	37.3	2.4	0.0	0.0	0.0	60.3
Chemistry	100.0	35.6	9.3	32.7	2.6	0.6	19.1
Physics	100.0	37.7	14.5	1.9	0.3	0.2	45.5
Other	100.0	0.0	0.0	43.8	0.0	0.0	56.3
Mathematics	100.0	43.6	19.0	7.0	2.7	2.0	25.8
Computer sciences	100.0	37.1	42.5	3.1	0.5	0.5	16.4
Environmental sciences	100.0	42.1	9.2	0.7	0.1	2.0	45.9
Atmospheric sciences	100.0	38.3	8.5	0.4	0.4	2.0	50.5
Earth sciences	100.0	53.8	2.1	0.2	0.0	1.0	42.9
Oceanography	100.0	33.6	20.4	1.1	0.0	0.5	44.5
Other	100.0	15.4	11.2	2.9	0.4	12.4	57.7
Life sciences	100.0	7.0	1.8	58.0	3.7	15.4	14.1
Agricultural sciences	100.0	4.0	1.4	0.8	0.3	60.5	33.1
Biological sciences	100.0	8.1	1.7	67.3	3.1	9.4	10.5
Medical sciences	100.0	3.3	3.2	69.3	7.5	4.1	12.6
Other	100.0	4.6	1.4	50.1	21.2	0.0	22.6
Psychology	100.0	8.4	7.7	53.5	9.7	1.1	19.6
Social sciences	100.0	16.2	3.9	9.6	3.1	26.7	40.5
Anthropology	100.0	16.7	6.9	16.7	0.0	1.0	58.8
Economics	100.0	7.3	0.8	1.3	2.6	57.8	30.2
History of science	100.0	100.0	0.0	0.0	0.0	0.0	0.0
Linguistics	100.0	44.8	6.9	19.0	3.4	0.0	25.9
Political science	100.0	14.8	3.5	4.3	6.1	8.7	62.6
Sociology	100.0	18.1	0.0	31.2	7.6	19.4	23.6
Other	100.0	22.3	9.1	6.3	1.2	6.7	54.4
Total engineering	100.0	29.1	27.7	4.2	0.9	2.4	35.7
Aeronautical/ astronautical	100.0	12.0	37.9	0.1	0.3	0.3	49.4
Chemical	100.0	42.3	10.5	5.2	1.1	4.1	36.8
Civil	100.0	28.3	14.0	1.8	0.6	3.0	52.2
Electrical/electronics	100.0	33.5	41.4	2.3	0.5	1.0	21.3
Industrial	100.0	31.9	17.9	2.7	5.4	0.0	42.2
Mechanical	100.0	24.8	29.2	2.9	0.3	0.2	42.7
Materials	100.0	31.2	31.1	0.8	0.8	0.2	35.8
Other	100.0	20.0	21.5	15.9	1.5	9.2	31.8

SOURCE: National Science Foundation, Science Resources Studies Division, Survey of Graduate Students and Postdoctorates in Science and Engineering, various years, unpublished tabulations.

See figure 5-23.

Science & Engineering Indicators – 1998

Appendix table 5-44.

U.S. scientific and technical journal articles, by sector and field: 1981-95

	Number of articles by:							Percent of articles by:						
	Total	Academia	Industry	Federal	FFRDC	Non-profit	Other	Total	Academia	Industry	Federal	FFRDC	Non-profit	Other
All natural science and engineering fields														
1981	132,280	90,412	11,141	13,099	4,791	9,959	2,883	100	68	8	10	4	8	2
1982	133,623	92,335	11,039	13,084	4,512	9,766	2,889	100	69	8	10	3	7	2
1983	132,416	90,556	11,760	12,880	4,627	9,932	2,665	100	68	9	10	3	8	2
1984	131,112	90,455	11,266	12,828	4,053	9,865	2,652	100	69	9	10	3	8	2
1985	137,771	95,340	11,767	12,899	4,917	10,188	2,662	100	69	9	9	4	7	2
1986	137,771	95,813	11,874	12,893	4,762	9,895	2,541	100	70	9	9	3	7	2
1987	134,498	94,424	11,273	12,255	4,619	9,546	2,383	100	70	8	9	3	7	2
1988	138,143	97,176	11,853	12,298	4,593	9,983	2,240	100	70	9	9	3	7	2
1989	140,833	99,214	11,964	12,373	4,533	10,360	2,390	100	70	8	9	3	7	2
1990	140,994	99,498	12,296	12,379	4,403	10,065	2,356	100	71	9	9	3	7	2
1991	142,334	100,276	12,660	12,266	4,392	10,244	2,499	100	70	9	9	3	7	2
1992	143,175	101,781	12,423	11,986	4,319	10,149	2,523	100	71	9	8	3	7	2
1993	140,588	100,049	11,757	11,796	3,987	10,500	2,501	100	71	8	8	3	7	2
1994	141,975	100,904	12,065	11,979	4,539	10,381	2,109	100	71	8	8	3	7	1
1995	142,792	101,458	11,791	11,858	4,792	10,755	2,141	100	71	8	8	3	8	1
Clinical medicine														
1981	48,073	32,841	1,563	4,995	256	6,746	1,673	100	68	3	10	1	14	3
1982	48,531	33,388	1,626	5,006	235	6,554	1,722	100	69	3	10	0	14	4
1983	48,056	32,872	1,732	4,916	207	6,746	1,584	100	68	4	10	0	14	3
1984	48,736	33,319	1,860	4,992	216	6,762	1,587	100	68	4	10	0	14	3
1985	50,596	35,008	1,834	4,972	288	6,943	1,551	100	69	4	10	1	14	3
1986	50,638	34,920	2,111	5,025	254	6,788	1,542	100	69	4	10	1	13	3
1987	49,905	34,787	2,075	4,867	203	6,498	1,475	100	70	4	10	0	13	3
1988	49,932	34,722	2,146	4,846	224	6,633	1,362	100	70	4	10	0	13	3
1989	50,510	34,938	2,380	4,685	193	6,841	1,472	100	69	5	9	0	14	3
1990	50,322	35,058	2,477	4,623	192	6,588	1,384	100	70	5	9	0	13	3
1991	50,142	34,794	2,545	4,510	195	6,678	1,420	100	69	5	9	0	13	3
1992	50,326	35,111	2,638	4,288	179	6,618	1,493	100	70	5	9	0	13	3
1993	50,258	34,659	2,685	4,306	185	6,968	1,454	100	69	5	9	0	14	3
1994	49,702	34,432	2,818	4,204	236	6,798	1,215	100	69	6	8	0	14	2
1995	50,343	34,818	2,955	4,067	230	7,021	1,253	100	69	6	8	0	14	2

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Appendix table 5-44.

U.S. scientific and technical journal articles, by sector and field: 1981-95

	Number of articles by:							Percent of articles by:						
	Total	Academia	Industry	Federal	FFRDC	Non-profit	Other	Total	Academia	Industry	Federal	FFRDC	Non-profit	Other
							Biomedical research							
1981	21,847	16,904	563	2,101	377	1,578	326	100	77	3	10	2	7	1
1982	22,732	17,704	568	2,085	336	1,702	337	100	78	2	9	1	7	1
1983	22,497	17,359	687	2,128	343	1,638	342	100	77	3	9	2	7	2
1984	22,196	17,112	771	2,044	280	1,652	338	100	77	3	9	1	7	2
1985	24,460	18,825	921	2,253	332	1,771	359	100	77	4	9	1	7	1
1986	24,765	18,797	1,164	2,291	343	1,818	352	100	76	5	9	1	7	1
1987	24,542	18,571	1,208	2,303	357	1,778	324	100	76	5	9	1	7	1
1988	25,072	19,073	1,263	2,220	361	1,882	272	100	76	5	9	1	8	1
1989	26,541	20,157	1,367	2,385	357	2,015	261	100	76	5	9	1	8	1
1990	26,660	20,279	1,382	2,336	379	1,977	308	100	76	5	9	1	7	1
1991	26,918	20,444	1,524	2,258	413	1,982	297	100	76	6	8	2	7	1
1992	27,782	21,255	1,535	2,273	360	2,050	309	100	77	6	8	1	7	1
1993	27,119	20,686	1,508	2,276	329	2,009	310	100	76	6	8	1	7	1
1994	27,465	20,880	1,597	2,244	358	2,121	265	100	76	6	8	1	8	1
1995	28,081	21,225	1,671	2,245	398	2,252	291	100	76	6	8	1	8	1
							Biology							
1981	14,740	11,053	332	2,221	130	553	451	100	75	2	15	1	4	3
1982	14,974	11,458	364	2,169	136	460	388	100	77	2	14	1	3	3
1983	14,216	10,804	342	2,136	113	471	351	100	76	2	15	1	3	2
1984	14,166	10,690	412	2,123	118	455	368	100	75	3	15	1	3	3
1985	13,083	10,077	383	1,792	96	398	337	100	77	3	14	1	3	3
1986	13,000	10,068	337	1,862	69	380	285	100	77	3	14	1	3	2
1987	12,231	9,547	359	1,670	72	328	255	100	78	3	14	1	3	2
1988	12,370	9,562	363	1,702	95	395	253	100	77	3	14	1	3	2
1989	12,726	9,705	385	1,812	85	431	308	100	76	3	14	1	3	2
1990	13,182	10,015	444	1,928	90	410	296	100	76	3	15	1	3	2
1991	12,862	9,743	439	1,875	59	422	325	100	76	3	15	0	3	3
1992	12,062	9,154	398	1,708	60	424	319	100	76	3	14	0	4	3
1993	11,304	8,583	395	1,595	65	375	292	100	76	3	14	1	3	3
1994	11,433	8,514	491	1,710	73	381	263	100	74	4	15	1	3	2
1995	11,167	8,334	487	1,659	71	372	244	100	75	4	15	1	3	2

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Appendix table 5-44.

U.S. scientific and technical journal articles, by sector and field: 1981-95

	Number of articles by:							Percent of articles by:						
	Total	Academia	Industry	Federal	FFRDC	Non-profit	Other	Total	Academia	Industry	Federal	FFRDC	Non-profit	Other
						Chemistry								
1981	10,880	7,647	1,798	687	437	243	68	100	70	17	6	4	2	1
1982	11,758	8,242	1,860	848	478	245	86	100	70	16	7	4	2	1
1983	11,010	7,710	1,880	716	420	214	71	100	70	17	7	4	2	1
1984	11,137	7,941	1,761	764	427	180	64	100	71	16	7	4	2	1
1985	11,585	8,137	1,951	794	418	217	68	100	70	17	7	4	2	1
1986	12,313	8,734	2,101	734	490	189	66	100	71	17	6	4	2	1
1987	11,827	8,455	2,010	694	439	182	48	100	71	17	6	4	2	0
1988	12,384	8,867	2,051	726	477	202	62	100	72	17	6	4	2	1
1989	12,405	9,025	1,960	685	490	190	55	100	73	16	6	4	2	0
1990	12,719	9,272	2,054	666	470	182	75	100	73	16	5	4	1	1
1991	13,086	9,447	2,122	699	485	239	95	100	72	16	5	4	2	1
1992	12,926	9,561	1,981	686	436	195	69	100	74	15	5	3	2	1
1993	13,252	9,789	2,045	633	443	272	70	100	74	15	5	3	2	1
1994	12,598	9,178	1,950	720	423	263	65	100	73	15	6	3	2	1
1995	12,900	9,495	1,874	699	536	248	48	100	74	15	5	4	2	0
						Physics								
1981	13,053	8,123	2,135	835	1,753	180	28	100	62	16	6	13	1	0
1982	13,255	8,195	2,224	848	1,748	202	38	100	62	17	6	13	2	0
1983	13,021	8,197	2,086	760	1,727	200	51	100	63	16	6	13	2	0
1984	12,691	8,118	2,007	754	1,567	199	47	100	64	16	6	12	2	0
1985	15,903	9,802	2,823	933	2,054	234	56	100	62	18	6	13	1	0
1986	16,361	10,129	2,881	917	2,195	206	33	100	62	18	6	13	1	0
1987	16,078	10,209	2,739	854	2,006	229	42	100	63	17	5	12	1	0
1988	17,499	11,111	3,024	936	2,159	231	37	100	63	17	5	12	1	0
1989	17,649	11,392	2,915	949	2,107	245	41	100	65	17	5	12	1	0
1990	17,242	11,113	2,939	905	2,008	236	41	100	64	17	5	12	1	0
1991	18,078	11,866	2,889	1,000	2,017	249	57	100	66	16	6	11	1	0
1992	17,848	11,814	2,812	1,026	1,919	214	62	100	66	16	6	11	1	0
1993	16,912	11,641	2,241	990	1,757	216	68	100	69	13	6	10	1	0
1994	18,836	13,116	2,228	1,121	2,093	242	36	100	70	12	6	11	1	0
1995	17,883	12,489	1,897	1,053	2,196	202	46	100	70	11	6	12	1	0

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Appendix table 5-44.
U.S. scientific and technical journal articles, by sector and field: 1981-95

	Number of articles by:							Percent of articles by:						
	Total	Academia	Industry	Federal	FFRDC	Non-profit	Other	Total	Academia	Industry	Federal	FFRDC	Non-profit	Other
Earth and space sciences														
1981	7,257	4,710	408	1,164	562	315	97	100	65	6	16	8	4	1
1982	7,057	4,529	461	1,092	554	312	109	100	64	7	15	8	4	2
1983	6,862	4,371	448	1,091	518	330	104	100	64	7	16	8	5	2
1984	6,748	4,329	447	1,062	523	296	92	100	64	7	16	8	4	1
1985	7,663	4,795	598	1,197	533	364	177	100	63	8	16	7	5	2
1986	7,811	4,985	580	1,206	579	285	178	100	64	7	15	7	4	2
1987	7,797	4,984	587	1,169	568	323	166	100	64	8	15	7	4	2
1988	7,653	4,916	516	1,120	526	418	157	100	64	7	15	7	5	2
1989	7,770	4,954	565	1,112	534	429	176	100	64	7	14	7	6	2
1990	7,716	4,941	481	1,147	548	457	142	100	64	6	15	7	6	2
1991	8,138	5,155	605	1,149	569	471	189	100	63	7	14	7	6	2
1992	8,233	5,363	596	1,149	552	416	159	100	65	7	14	7	5	2
1993	8,522	5,631	522	1,186	561	453	170	100	66	6	14	7	5	2
1994	8,904	5,826	625	1,258	621	417	158	100	65	7	14	7	5	2
1995	9,378	6,132	579	1,311	710	481	166	100	65	6	14	8	5	2
Engineering and technology														
1981	12,486	5,555	4,191	1,009	1,220	283	229	100	44	34	8	10	2	2
1982	11,619	5,518	3,778	926	974	220	202	100	47	33	8	8	2	2
1983	13,105	5,936	4,419	1,071	1,252	270	157	100	45	34	8	10	2	1
1984	11,976	5,830	3,870	999	874	256	149	100	49	32	8	7	2	1
1985	10,822	5,442	3,081	847	1,152	198	103	100	50	28	8	11	2	1
1986	9,774	5,369	2,579	790	776	180	81	100	55	26	8	8	2	1
1987	9,225	5,291	2,165	630	921	151	67	100	57	23	7	10	2	1
1988	9,488	5,537	2,336	660	698	171	86	100	58	25	7	7	2	1
1989	9,568	5,676	2,266	678	715	169	65	100	59	24	7	7	2	1
1990	10,113	6,084	2,402	694	677	159	98	100	60	24	7	7	2	1
1991	9,999	5,978	2,441	715	608	153	104	100	60	24	7	6	2	1
1992	10,833	6,634	2,333	809	776	176	105	100	61	22	7	7	2	1
1993	10,051	6,185	2,242	736	601	158	130	100	62	22	7	6	2	1
1994	10,058	6,210	2,262	677	693	121	94	100	62	22	7	7	1	1
1995	10,229	6,370	2,240	774	623	136	87	100	62	22	8	6	1	1

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Appendix table 5-44.

U.S. scientific and technical journal articles, by sector and field: 1981-95

	Number of articles by:							Percent of articles by:						
	Total	Academia	Industry	Federal	FFRDC	Non-profit	Other	Total	Academia	Industry	Federal	FFRDC	Non-profit	Other
							Mathematics							
1981	3,944	3,579	151	87	56	61	11	100	91	4	2	1	2	0
1982	3,697	3,301	158	110	51	71	7	100	89	4	3	1	2	0
1983	3,649	3,307	166	62	47	63	5	100	91	5	2	1	2	0
1984	3,462	3,116	138	90	48	65	7	100	90	4	3	1	2	0
1985	3,659	3,254	176	111	44	63	11	100	89	5	3	1	2	0
1986	3,109	2,811	121	68	56	49	4	100	90	4	2	2	2	0
1987	2,893	2,580	130	68	53	57	6	100	89	4	2	2	2	0
1988	3,745	3,388	154	88	53	51	11	100	90	4	2	1	1	0
1989	3,664	3,367	126	67	52	40	12	100	92	3	2	1	1	0
1990	3,040	2,736	117	80	39	56	12	100	90	4	3	1	2	0
1991	3,111	2,849	95	60	46	50	12	100	92	3	2	1	2	0
1992	3,165	2,889	130	47	37	56	7	100	91	4	1	1	2	0
1993	3,170	2,875	119	74	46	49	7	100	91	4	2	1	2	0
1994	2,979	2,748	94	45	42	38	13	100	92	3	2	1	1	0
1995	2,811	2,595	88	50	28	43	6	100	92	3	2	1	2	0

NOTE: Percentages may not total 100 because of rounding.

SOURCES: Institute for Scientific Information, Science Citation Index; CHI Research Inc., Science Indicators database; and National Science Foundation, unpublished tabulations.

Appendix table 5-45.

Broad and fine fields for publications output data

Broad field	Fine fields		
Clinical medicine	Addictive diseases	Geriatrics	Pathology
	Allergy	Hematology	Pediatrics
	Anesthesiology	Hygiene & public health	Pharmacology
	Arthritis & rheumatism	Immunology	Pharmacy
	Cancer	Miscellaneous clinical	Psychiatry
	Cardiovascular system	Nephrology	Radiology & nuclear medicine
	Dentistry	Neurology & neurosurgery	Respiratory system
	Dermatology & venereal disease	Obstetrics & gynecology	Surgery
	Endocrinology	Ophthalmology	Tropical medicine
	Fertility	Orthopedics	Urology
	Gastroenterology	Otorhinolaryngology	Veterinary medicine
	General & internal medicine		
Biomedical research	Anatomy & morphology	Embryology	Miscellaneous biomedical research
	Biochemistry & molecular biology	Genetics & heredity	Nutrition & dietetics
	Biomedical engineering	General biomedical research	Parasitology
	Biophysics	Microbiology	Physiology
	Cell biology, cytology & histology	Microscopy	Virology
Biology	Agriculture & food science	Entomology	Marine and hydro-biology
	Botany	General biology	Miscellaneous biology
	Dairy & animal science	General zoology	Miscellaneous zoology
	Ecology		
Chemistry	Analytical chemistry	Inorganic & nuclear chemistry	Physical chemistry
	Applied chemistry	Organic chemistry	Polymers
	General chemistry		
Physics	Acoustics	Fluids & plasmas	Nuclear & particle physics
	Applied physics	General physics	Optics
	Chemical physics	Miscellaneous physics	Solid state physics
Earth and space sciences	Astronomy & astrophysics	Geography	Meteorology & atmospheric science
	Earth & planetary science	Geology	Oceanography & limnology
	Environmental science	General engineering	Metals & metallurgy
Engineering and technology	Aerospace technology	Industrial engineering	Miscellaneous engineering & technology
	Chemical engineering	Library & information science	Nuclear technology
	Civil engineering	Materials science	Operations research & management
	Computers	Mechanical engineering	
	Electrical engineering & electronics		
Mathematics	Applied mathematics	Miscellaneous mathematics	Probability & statistics
	General mathematics		

SOURCE: CHI Research, Inc., Science Indicators database.

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Appendix table 5-46.

Coauthorship of U.S. scientific and technical articles across sectors, by article field: 1981-95

Sector	Number of multisector articles coauthored by:						Percent of all articles coauthored by:						
	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others	All sectors	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others
						All natural science and engineering fields							
Academia													
1981	NA	2,905	8,138	2,072	7,352	2,384	20.4	NA	2.8	7.8	2.0	7.1	2.3
1983	NA	3,386	8,234	2,160	7,798	2,429	20.9	NA	3.2	7.8	2.1	7.4	2.3
1985	NA	4,063	8,694	2,406	8,326	2,461	21.3	NA	3.6	7.8	2.2	7.5	2.2
1987	NA	4,598	9,104	2,684	8,286	2,477	22.1	NA	4.1	8.2	2.4	7.4	2.2
1989	NA	5,301	9,163	2,783	9,005	2,633	22.1	NA	4.5	7.8	2.4	7.6	2.2
1991	NA	6,199	9,334	3,054	9,237	2,806	22.6	NA	5.1	7.7	2.5	7.7	2.3
1993	NA	6,611	9,626	3,282	9,537	2,932	23.1	NA	5.4	7.9	2.7	7.8	2.4
1995	NA	7,479	10,442	3,863	10,326	2,708	24.2	NA	5.9	8.3	3.1	8.2	2.2
Industry													
1981	2,905	NA	639	248	296	172	27.3	21.6	NA	4.7	1.8	2.2	1.3
1983	3,386	NA	837	352	404	235	30.4	23.2	NA	5.7	2.4	2.8	1.6
1985	4,063	NA	901	380	514	241	34.0	26.9	NA	6.0	2.5	3.4	1.6
1987	4,598	NA	1,029	417	639	266	38.0	30.5	NA	6.8	2.8	4.2	1.8
1989	5,301	NA	1,215	455	814	311	40.4	32.3	NA	7.4	2.8	5.0	1.9
1991	6,199	NA	1,358	518	878	379	42.5	34.6	NA	7.6	2.9	4.9	2.1
1993	6,611	NA	1,565	550	1,094	464	47.0	37.8	NA	9.0	3.1	6.3	2.7
1995	7,479	NA	1,719	735	1,239	501	50.2	40.8	NA	9.4	4.0	6.8	2.7
Federal Government													
1981	8,138	639	NA	265	818	423	49.4	43.8	3.4	NA	1.4	4.4	2.3
1983	8,234	837	NA	272	838	441	50.5	44.4	4.5	NA	1.5	4.5	2.4
1985	8,694	901	NA	303	961	508	52.0	45.7	4.7	NA	1.6	5.0	2.7
1987	9,104	1,029	NA	331	985	529	55.1	48.6	5.5	NA	1.8	5.3	2.8
1989	9,163	1,215	NA	427	1,067	481	55.2	47.9	6.4	NA	2.2	5.6	2.5
1991	9,334	1,358	NA	419	1,173	552	55.9	48.2	7.0	NA	2.2	6.1	2.9
1993	9,626	1,565	NA	438	1,224	691	58.0	49.9	8.1	NA	2.3	6.3	3.6
1995	10,442	1,719	NA	620	1,435	618	60.2	52.2	8.6	NA	3.1	7.2	3.1
FFRDCs													
1981	2,072	248	265	NA	85	21	38.7	32.4	3.9	4.1	NA	1.3	0.3
1983	2,160	352	272	NA	107	41	41.8	33.7	5.5	4.2	NA	1.7	0.6
1985	2,406	380	303	NA	132	29	43.1	34.6	5.5	4.4	NA	1.9	0.4
1987	2,684	417	331	NA	129	35	47.2	39.0	6.1	4.8	NA	1.9	0.5
1989	2,783	455	427	NA	164	38	49.4	40.1	6.6	6.2	NA	2.4	0.5
1991	3,054	518	419	NA	207	37	52.7	43.4	7.4	6.0	NA	2.9	0.5
1993	3,282	550	438	NA	198	48	57.4	47.7	8.0	6.4	NA	2.9	0.7
1995	3,863	735	620	NA	279	71	55.8	45.9	8.7	7.4	NA	3.3	0.8

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Appendix table 5-46.

Coauthorship of U.S. scientific and technical articles across sectors, by article field: 1981-95

Sector	Number of multisector articles coauthored by:						Percent of all articles coauthored by:						
	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others	All sectors	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others
Nonprofits													
1981	7,352	296	818	85	NA	486	54.9	50.3	2.0	5.6	0.6	NA	3.3
1983	7,798	404	838	107	NA	519	56.8	52.3	2.7	5.6	0.7	NA	3.5
1985	8,326	514	961	132	NA	547	58.1	53.2	3.3	6.1	0.8	NA	3.5
1987	8,286	639	985	129	NA	515	59.7	55.0	4.2	6.5	0.9	NA	3.4
1989	9,005	814	1,067	164	NA	589	59.9	54.6	4.9	6.5	1.0	NA	3.6
1991	9,237	878	1,173	207	NA	767	61.1	55.3	5.3	7.0	1.2	NA	4.6
1993	9,537	1,094	1,224	198	NA	861	60.9	55.1	6.3	7.1	1.1	NA	5.0
1995	10,326	1,239	1,435	279	NA	770	62.4	56.8	6.8	7.9	1.5	NA	4.2
Other													
1981	2,384	172	423	21	486	NA	62.2	51.8	3.7	9.2	0.5	10.6	NA
1983	2,429	235	441	41	519	NA	65.5	54.4	5.3	9.9	0.9	11.6	NA
1985	2,461	241	508	29	547	NA	66.3	54.3	5.3	11.2	0.6	12.1	NA
1987	2,477	266	529	35	515	NA	69.7	58.4	6.3	12.5	0.8	12.1	NA
1989	2,633	311	481	38	589	NA	71.8	59.8	7.1	10.9	0.9	13.4	NA
1991	2,806	379	552	37	767	NA	71.9	59.9	8.1	11.8	0.8	16.4	NA
1993	2,932	464	691	48	861	NA	73.4	59.9	9.5	14.1	1.0	17.6	NA
1995	2,708	501	618	71	770	NA	75.8	62.2	11.5	14.2	1.6	17.7	NA
Clinical medicine													
Academia													
1981	NA	636	4,698	119	5,479	1,718	29.6	NA	1.6	12.0	0.3	14.0	4.4
1983	NA	779	4,469	130	5,738	1,752	29.6	NA	2.0	11.3	0.3	14.5	4.4
1985	NA	1,080	4,718	166	6,072	1,763	29.6	NA	2.6	11.2	0.4	14.4	4.2
1987	NA	1,322	4,993	157	5,948	1,802	30.1	NA	3.1	11.8	0.4	14.1	4.3
1989	NA	1,584	4,789	161	6,177	1,881	30.5	NA	3.7	11.3	0.4	14.5	4.4
1991	NA	1,880	4,611	157	6,219	1,911	30.3	NA	4.4	10.8	0.4	14.6	4.5
1993	NA	2,102	4,636	158	6,507	2,004	30.8	NA	4.9	10.8	0.4	15.2	4.7
1995	NA	2,457	4,791	229	6,700	1,822	31.3	NA	5.6	11.0	0.5	15.4	4.2
Industry													
1981	636	NA	151	14	173	72	39.0	30.5	NA	7.2	0.7	8.3	3.5
1983	779	NA	193	10	240	103	42.2	32.5	NA	8.1	0.4	10.0	4.3
1985	1,080	NA	247	28	278	103	49.0	39.6	NA	9.1	1.0	10.2	3.8
1987	1,322	NA	301	38	385	152	51.2	41.5	NA	9.5	1.2	12.1	4.8
1989	1,584	NA	353	37	516	165	52.9	42.1	NA	9.4	1.0	13.7	4.4
1991	1,880	NA	415	29	533	222	54.4	45.3	NA	10.0	0.7	12.8	5.3
1993	2,102	NA	468	42	701	266	55.7	46.2	NA	10.3	0.9	15.4	5.8
1995	2,457	NA	509	51	786	317	56.9	47.7	NA	9.9	1.0	15.3	6.2

Appendix table 5-46.

Coauthorship of U.S. scientific and technical articles across sectors, by article field: 1981-95

	Number of multisector articles coauthored by:						Percent of all articles coauthored by:						
Sector	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others	All sectors	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others
Federal Government													
1981	4,698	151	NA	28	556	273	63.5	59.1	1.9	NA	0.4	7.0	3.4
1983	4,469	193	NA	28	584	279	62.1	57.4	2.5	NA	0.4	7.5	3.6
1985	4,718	247	NA	48	658	347	63.5	58.1	3.0	NA	0.6	8.1	4.3
1987	4,993	301	NA	53	661	359	65.7	60.9	3.7	NA	0.6	8.1	4.4
1989	4,789	353	NA	64	690	334	65.8	60.2	4.4	NA	0.8	8.7	4.2
1991	4,611	415	NA	53	718	351	65.3	59.3	5.3	NA	0.7	9.2	4.5
1993	4,636	468	NA	57	773	438	66.7	60.3	6.1	NA	0.7	10.1	5.7
1995	4,791	509	NA	94	929	408	69.5	62.9	6.7	NA	1.2	12.2	5.4
FFRDCs													
1981	119	14	28	NA	21	5	45.6	33.5	3.9	7.9	NA	5.9	1.4
1983	130	10	28	NA	28	5	53.5	41.7	3.2	9.0	NA	9.0	1.6
1985	166	28	48	NA	43	6	53.6	38.3	6.5	11.1	NA	9.9	1.4
1987	143	16	34	NA	34	10	55.2	42.4	4.7	10.1	NA	10.1	3.0
1989	157	38	53	NA	26	4	58.8	45.5	11.0	15.4	NA	7.5	1.2
1991	161	37	64	NA	32	12	64.5	46.5	10.7	18.5	NA	9.2	3.5
1993	157	29	53	NA	36	7	62.0	45.9	8.5	15.5	NA	10.5	2.0
1995	158	42	57	NA	30	4	66.9	45.1	12.0	16.3	NA	8.6	1.1
Nonprofits													
1981	5,479	173	556	25	NA	403	58.3	54.4	1.7	5.5	0.2	NA	4.0
1983	5,738	240	584	28	NA	438	59.9	56.1	2.3	5.7	0.3	NA	4.3
1985	6,072	278	658	43	NA	461	60.7	56.6	2.6	6.1	0.4	NA	4.3
1987	5,948	385	661	26	NA	452	62.0	58.0	3.8	6.4	0.3	NA	4.4
1989	6,177	516	690	32	NA	482	61.7	57.0	4.8	6.4	0.3	NA	4.5
1991	6,219	533	718	36	NA	627	62.7	57.8	5.0	6.7	0.3	NA	5.8
1993	6,507	701	773	30	NA	727	62.1	57.5	6.2	6.8	0.3	NA	6.4
1995	6,700	786	929	40	NA	643	62.9	57.9	6.8	8.0	0.3	NA	5.6
Other													
1981	1,718	72	273	6	403	NA	69.5	59.6	2.5	9.5	0.2	14.0	NA
1983	1,752	103	279	5	438	NA	71.8	62.0	3.6	9.9	0.2	15.5	NA
1985	1,763	103	347	6	461	NA	73.5	62.0	3.6	12.2	0.2	16.2	NA
1987	1,802	152	359	4	452	NA	74.9	64.6	5.5	12.9	0.1	16.2	NA
1989	1,881	165	334	12	482	NA	76.6	65.5	5.7	11.6	0.4	16.8	NA
1991	1,911	222	351	7	627	NA	78.1	66.4	7.7	12.2	0.2	21.8	NA
1993	2,004	266	438	4	727	NA	77.8	66.2	8.8	14.5	0.1	24.0	NA
1995	1,822	317	408	14	643	NA	80.1	66.8	11.6	15.0	0.5	23.6	NA

Appendix table 5-46.

Coauthorship of U.S. scientific and technical articles across sectors, by article field: 1981-95

Sector	Number of multisector articles coauthored by:						Percent of all articles coauthored by:						
	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others	All sectors	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others
							Biomedical research						
Academia													
1981	NA	276	1,270	202	1,175	236	15.7	NA	1.5	6.7	1.1	6.2	1.2
1983	NA	334	1,316	181	1,296	269	16.1	NA	1.7	6.7	0.9	6.6	1.4
1985	NA	534	1,578	200	1,564	301	17.8	NA	2.5	7.3	0.9	7.3	1.4
1987	NA	718	1,652	223	1,610	301	19.1	NA	3.3	7.7	1.0	7.5	1.4
1989	NA	790	1,815	243	1,920	318	19.6	NA	3.4	7.7	1.0	8.2	1.4
1991	NA	935	1,772	323	1,959	376	20.0	NA	3.9	7.3	1.3	8.1	1.6
1993	NA	1,045	1,825	303	2,000	361	20.1	NA	4.2	7.4	1.2	8.1	1.5
1995	NA	1,216	2,013	395	2,393	378	22.1	NA	4.7	7.8	1.5	9.3	1.5
Industry													
1981	276	NA	57	20	40	14	43.4	35.3	NA	7.3	2.6	5.1	1.8
1983	334	NA	95	18	62	20	44.5	34.6	NA	9.8	1.9	6.4	2.1
1985	534	NA	146	22	90	31	48.3	38.8	NA	10.6	1.6	6.5	2.3
1987	718	NA	191	33	135	28	49.0	39.6	NA	10.5	1.8	7.5	1.5
1989	790	NA	208	41	163	35	47.0	38.8	NA	10.2	2.0	8.0	1.7
1991	935	NA	205	51	186	31	48.7	40.1	NA	8.8	2.2	8.0	1.3
1993	1,045	NA	227	48	222	42	52.1	43.2	NA	9.4	2.0	9.2	1.7
1995	1,216	NA	229	56	284	50	52.9	44.1	NA	8.3	2.0	10.3	1.8
Federal Government													
1981	1,270	57	NA	48	145	35	47.7	42.6	1.9	NA	1.6	4.9	1.2
1983	1,316	95	NA	38	135	46	48.1	43.2	3.1	NA	1.2	4.4	1.5
1985	1,578	146	NA	63	165	54	51.7	46.7	4.3	NA	1.9	4.9	1.6
1987	1,652	191	NA	71	198	46	53.0	46.9	5.4	NA	2.0	5.6	1.3
1989	1,815	208	NA	92	216	39	54.0	48.1	5.5	NA	2.4	5.7	1.0
1991	1,772	205	NA	95	253	55	55.8	48.5	5.6	NA	2.6	6.9	1.5
1993	1,825	227	NA	72	225	80	54.8	48.9	6.1	NA	1.9	6.0	2.1
1995	2,013	229	NA	102	248	73	58.1	52.4	6.0	NA	2.7	6.5	1.9
FFRDCs													
1981	202	20	48	NA	21	3	47.1	38.0	3.8	9.0	NA	4.0	0.6
1983	181	18	38	NA	27	11	44.9	37.3	3.7	7.8	NA	5.6	2.3
1985	200	22	63	NA	26	8	52.7	39.9	4.4	12.6	NA	5.2	1.6
1987	223	33	71	NA	27	12	55.3	39.9	5.9	12.7	NA	4.8	2.1
1989	243	41	92	NA	25	8	55.6	41.7	7.0	15.8	NA	4.3	1.4
1991	323	51	95	NA	55	8	59.4	46.1	7.3	13.6	NA	7.9	1.1
1993	303	48	72	NA	42	8	64.2	50.7	8.0	12.0	NA	7.0	1.3
1995	395	56	102	NA	80	8	64.3	52.2	7.4	13.5	NA	10.6	1.1

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Appendix table 5-46.

Coauthorship of U.S. scientific and technical articles across sectors, by article field: 1981-95

Sector	Number of multisector articles coauthored by:						Percent of all articles coauthored by:						
	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others	All sectors	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others
Nonprofits													
1981	1,175	40	145	20	NA	53	55.3	49.7	1.7	6.1	0.8	NA	2.2
1983	1,296	62	135	27	NA	51	55.7	51.3	2.5	5.3	1.1	NA	2.0
1985	1,564	90	165	26	NA	56	59.5	55.0	3.2	5.8	0.9	NA	2.0
1987	1,610	135	198	27	NA	46	60.1	55.1	4.6	6.8	0.9	NA	1.6
1989	1,920	163	216	25	NA	73	61.7	57.1	4.8	6.4	0.7	NA	2.2
1991	1,959	186	253	55	NA	91	63.4	57.5	5.5	7.4	1.6	NA	2.7
1993	2,000	222	225	42	NA	78	62.4	57.1	6.3	6.4	1.2	NA	2.2
1995	2,393	284	248	80	NA	89	64.6	59.5	7.1	6.2	2.0	NA	2.2
Other													
1981	236	14	35	5	53	NA	56.0	47.2	2.8	7.0	1.0	10.6	NA
1983	269	20	46	11	51	NA	59.0	49.6	3.7	8.5	2.0	9.4	NA
1985	301	31	54	8	56	NA	58.9	51.3	5.3	9.2	1.4	9.5	NA
1987	301	28	46	12	46	NA	64.0	54.2	5.0	8.3	2.2	8.3	NA
1989	318	35	39	8	73	NA	71.4	62.7	6.9	7.7	1.6	14.4	NA
1991	376	31	55	8	91	NA	72.9	63.6	5.2	9.3	1.4	15.4	NA
1993	361	42	80	8	78	NA	70.9	59.1	6.9	13.1	1.3	12.8	NA
1995	378	50	73	8	89	NA	72.7	62.6	8.3	12.1	1.3	14.7	NA
						Biology							
Academia													
1981	NA	176	829	49	221	262	12.2	NA	1.5	6.9	0.4	1.8	2.2
1983	NA	210	1,024	48	247	213	13.8	NA	1.8	8.6	0.4	2.1	1.8
1985	NA	242	852	50	194	202	13.1	NA	2.2	7.6	0.4	1.7	1.8
1987	NA	204	871	58	182	163	13.2	NA	1.9	8.2	0.5	1.7	1.5
1989	NA	285	902	50	232	242	14.7	NA	2.6	8.2	0.5	2.1	2.2
1991	NA	296	989	45	225	234	15.0	NA	2.7	8.9	0.4	2.0	2.1
1993	NA	316	894	59	213	252	16.2	NA	3.2	8.9	0.6	2.1	2.5
1995	NA	386	1,020	69	254	210	18.0	NA	3.9	10.4	0.7	2.6	2.1
Industry													
1981	176	NA	41	5	6	13	46.9	38.9	NA	9.1	1.1	1.3	2.9
1983	210	NA	70	13	13	18	54.2	42.0	NA	14.0	2.6	2.6	3.6
1985	242	NA	50	5	7	21	50.5	43.8	NA	9.0	0.9	1.3	3.8
1987	204	NA	36	2	9	13	47.0	40.6	NA	7.2	0.4	1.8	2.6
1989	285	NA	58	9	11	21	57.1	47.9	NA	9.7	1.5	1.8	3.5
1991	296	NA	72	3	13	21	52.8	45.1	NA	11.0	0.5	2.0	3.2
1993	316	NA	89	6	18	19	60.0	49.4	NA	13.9	0.9	2.8	3.0
1995	386	NA	98	8	23	28	57.3	49.3	NA	12.5	1.0	2.9	3.6

Appendix table 5-46.

Coauthorship of U.S. scientific and technical articles across sectors, by article field: 1981-95

Sector	Number of multisector articles coauthored by:						Percent of all articles coauthored by:						
	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others	All sectors	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others
Federal Government													
1981	829	41	NA	11	38	66	33.5	29.9	1.5	NA	0.4	1.4	2.4
1983	1,024	70	NA	12	45	69	40.6	36.5	2.5	NA	0.4	1.6	2.5
1985	852	50	NA	7	26	64	39.9	36.1	2.1	NA	0.3	1.1	2.7
1987	871	36	NA	7	24	61	41.8	39.0	1.6	NA	0.3	1.1	2.7
1989	902	58	NA	7	41	58	41.2	37.1	2.4	NA	0.3	1.7	2.4
1991	989	72	NA	13	41	72	42.7	38.7	2.8	NA	0.5	1.6	2.8
1993	894	89	NA	13	32	77	45.5	40.1	4.0	NA	0.6	1.4	3.5
1995	1,020	98	NA	21	57	68	47.2	42.9	4.1	NA	0.9	2.4	2.9
FFRDCs													
1981	49	5	11	NA	1	3	37.1	29.3	3.0	6.6	NA	0.6	1.8
1983	48	13	12	NA	5	2	42.3	30.8	8.3	7.7	NA	3.2	1.3
1985	50	5	7	NA	2	5	45.5	37.3	3.7	5.2	NA	1.5	3.7
1987	58	2	7	NA	2	1	57.1	51.8	1.8	6.3	NA	1.8	0.9
1989	50	9	7	NA	1	1	45.2	40.3	7.3	5.6	NA	0.8	0.8
1991	45	3	13	NA	2	3	58.1	48.4	3.2	14.0	NA	2.2	3.2
1993	59	6	13	NA	5	4	65.5	52.2	5.3	11.5	NA	4.4	3.5
1995	69	8	21	NA	2	2	61.8	52.7	6.1	16.0	NA	1.5	1.5
Nonprofits													
1981	221	6	38	2	NA	20	36.2	30.4	0.8	5.2	0.3	NA	2.8
1983	247	13	45	5	NA	18	44.5	37.8	2.0	6.9	0.8	NA	2.8
1985	194	7	26	2	NA	17	41.1	35.3	1.3	4.7	0.4	NA	3.1
1987	182	9	24	2	NA	10	44.8	39.0	1.9	5.1	0.4	NA	2.1
1989	232	11	41	1	NA	12	43.2	37.4	1.8	6.6	0.2	NA	1.9
1991	225	13	41	2	NA	23	42.5	36.6	2.1	6.7	0.3	NA	3.7
1993	213	18	32	5	NA	24	46.4	37.8	3.2	5.7	0.9	NA	4.3
1995	254	23	57	2	NA	18	50.1	43.1	3.9	9.7	0.3	NA	3.1
Other													
1981	262	13	66	0	20	NA	51.9	41.3	2.1	10.4	0.0	3.2	NA
1983	213	18	69	2	18	NA	54.6	41.1	3.5	13.3	0.4	3.5	NA
1985	202	21	64	5	17	NA	55.1	40.6	4.2	12.9	1.0	3.4	NA
1987	163	13	61	1	10	NA	54.9	43.0	3.4	16.1	0.3	2.6	NA
1989	242	21	58	1	12	NA	61.5	49.8	4.3	11.9	0.2	2.5	NA
1991	234	21	72	3	23	NA	58.4	46.2	4.1	14.2	0.6	4.5	NA
1993	252	19	77	4	24	NA	65.7	50.9	3.8	15.6	0.8	4.8	NA
1995	210	28	68	2	18	NA	63.3	52.1	6.9	16.9	0.5	4.5	NA

Appendix table 5-46.

Coauthorship of U.S. scientific and technical articles across sectors, by article field: 1981-95

	Number of multisector articles coauthored by:						Percent of all articles coauthored by:						
Sector	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others	All sectors	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others
						Chemistry							
Academia													
1981	NA	269	188	194	101	23	8.9	NA	3.2	2.2	2.3	1.2	0.3
1983	NA	328	202	182	90	19	9.2	NA	3.9	2.4	2.1	1.1	0.2
1985	NA	365	227	183	74	29	9.3	NA	4.1	2.5	2.0	0.8	0.3
1987	NA	468	225	255	71	25	10.6	NA	5.0	2.4	2.7	0.8	0.3
1989	NA	518	226	293	76	17	10.7	NA	5.1	2.2	2.9	0.8	0.2
1991	NA	622	260	298	123	59	11.9	NA	5.8	2.4	2.8	1.1	0.5
1993	NA	656	263	332	111	38	11.7	NA	5.9	2.3	3.0	1.0	0.3
1995	NA	717	311	409	150	40	13.8	NA	6.5	2.8	3.7	1.4	0.4
Industry													
1981	269	NA	24	9	12	7	14.9	13.5	NA	1.2	0.5	0.6	0.4
1983	328	NA	52	27	11	9	18.3	15.3	NA	2.4	1.3	0.5	0.4
1985	365	NA	37	20	23	9	18.9	16.4	NA	1.7	0.9	1.0	0.4
1987	468	NA	59	32	19	7	23.1	19.8	NA	2.5	1.4	0.8	0.3
1989	518	NA	78	41	13	11	26.1	21.9	NA	3.3	1.7	0.5	0.5
1991	622	NA	91	42	26	24	27.8	23.8	NA	3.5	1.6	1.0	0.9
1993	656	NA	91	57	29	17	30.0	25.5	NA	3.5	2.2	1.1	0.7
1995	717	NA	99	48	13	11	33.0	29.0	NA	4.0	1.9	0.5	0.4
Federal Government													
1981	188	24	NA	2	10	3	25.8	22.9	2.9	NA	0.2	1.2	0.4
1983	202	52	NA	10	13	5	29.1	22.8	5.9	NA	1.1	1.5	0.6
1985	227	37	NA	9	17	3	27.9	23.4	3.8	NA	0.9	1.8	0.3
1987	225	59	NA	5	12	5	32.5	25.6	6.7	NA	0.6	1.4	0.6
1989	226	78	NA	14	13	3	35.1	25.6	8.8	NA	1.6	1.5	0.3
1991	260	91	NA	25	20	20	38.1	27.8	9.7	NA	2.7	2.1	2.1
1993	263	91	NA	15	28	13	40.4	29.8	10.3	NA	1.7	3.2	1.5
1995	311	99	NA	33	10	6	40.6	32.1	10.2	NA	3.4	1.0	0.6
FFRDCs													
1981	194	9	2	NA	0	1	37.1	34.5	1.6	0.4	NA	0.0	0.2
1983	182	27	10	NA	3	0	39.3	32.5	4.8	1.8	NA	0.5	0.0
1985	183	20	9	NA	2	0	39.6	33.2	3.6	1.6	NA	0.4	0.0
1987	255	32	5	NA	3	1	46.0	41.3	5.2	0.8	NA	0.5	0.2
1989	293	41	14	NA	1	0	47.6	42.2	5.9	2.0	NA	0.1	0.0
1991	298	42	25	NA	9	2	49.6	42.2	5.9	3.5	NA	1.3	0.3
1993	332	57	15	NA	3	3	54.2	48.6	8.3	2.2	NA	0.4	0.4
1995	409	48	33	NA	6	6	55.5	48.6	5.7	3.9	NA	0.7	0.7

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Appendix table 5-46.

Coauthorship of U.S. scientific and technical articles across sectors, by article field: 1981-95

Sector	Number of multisector articles coauthored by:						Percent of all articles coauthored by:						
	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others	All sectors	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others
Nonprofits													
1981	101	12	10	4	NA	1	37.0	32.0	3.8	3.2	1.3	NA	0.3
1983	90	11	13	3	NA	1	38.7	31.9	3.9	4.6	1.1	NA	0.4
1985	74	23	17	2	NA	1	36.1	26.0	8.1	6.0	0.7	NA	0.4
1987	71	19	12	3	NA	2	37.1	28.3	7.6	4.8	1.2	NA	0.8
1989	76	13	13	1	NA	0	37.7	29.2	5.0	5.0	0.4	NA	0.0
1991	123	26	20	9	NA	5	45.0	35.2	7.4	5.7	2.6	NA	1.4
1993	111	29	28	3	NA	4	40.8	29.8	7.8	7.5	0.8	NA	1.1
1995	150	13	10	6	NA	1	45.2	40.9	3.5	2.7	1.6	NA	0.3
Other													
1981	23	7	3	1	1	NA	34.9	26.7	8.1	3.5	1.2	1.2	NA
1983	19	9	5	0	1	NA	28.3	20.7	9.8	5.4	0.0	1.1	NA
1985	29	9	3	0	1	NA	39.6	31.9	9.9	3.3	0.0	1.1	NA
1987	25	7	5	1	2	NA	51.4	34.7	9.7	6.9	1.4	2.8	NA
1989	17	11	3	0	0	NA	41.1	23.3	15.1	4.1	0.0	0.0	NA
1991	59	24	20	2	5	NA	56.3	41.0	16.7	13.9	1.4	3.5	NA
1993	38	17	13	3	4	NA	55.0	34.2	15.3	11.7	2.7	3.6	NA
1995	40	11	6	6	1	NA	67.5	50.0	13.8	7.5	7.5	1.3	NA
Physics													
Academia													
1981	NA	508	298	856	89	8	17.5	NA	5.3	3.1	9.0	0.9	0.1
1983	NA	603	340	998	126	28	19.8	NA	6.2	3.5	10.2	1.3	0.3
1985	NA	806	385	1,153	116	27	19.8	NA	6.8	3.3	9.8	1.0	0.2
1987	NA	878	400	1,301	124	22	20.4	NA	7.1	3.2	10.5	1.0	0.2
1989	NA	1,047	490	1,327	157	25	20.2	NA	7.5	3.5	9.6	1.1	0.2
1991	NA	1,229	562	1,442	203	42	21.2	NA	8.3	3.8	9.7	1.4	0.3
1993	NA	1,180	681	1,576	178	59	22.1	NA	7.9	4.5	10.5	1.2	0.4
1995	NA	1,189	719	1,762	204	44	21.5	NA	7.3	4.4	10.8	1.2	0.3
Industry													
1981	508	NA	77	75	6	3	24.2	19.9	NA	3.0	2.9	0.2	0.1
1983	603	NA	99	131	19	14	29.2	23.0	NA	3.8	5.0	0.7	0.5
1985	806	NA	120	155	22	12	28.7	23.0	NA	3.4	4.4	0.6	0.3
1987	878	NA	114	177	23	12	30.8	25.1	NA	3.3	5.1	0.7	0.3
1989	1,047	NA	187	197	27	7	33.9	27.6	NA	4.9	5.2	0.7	0.2
1991	1,229	NA	234	259	38	17	38.7	31.0	NA	5.9	6.5	1.0	0.4
1993	1,180	NA	247	245	35	26	44.9	35.8	NA	7.5	7.4	1.1	0.8
1995	1,189	NA	254	338	24	18	51.4	39.9	NA	8.5	11.3	0.8	0.6

Appendix table 5-46.

Coauthorship of U.S. scientific and technical articles across sectors, by article field: 1981-95

Sector	Number of multisector articles coauthored by:						Percent of all articles coauthored by:						
	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others	All sectors	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others
Federal Government													
1981	298	77	NA	54	7	5	35.9	27.5	7.1	NA	5.0	0.6	0.5
1983	340	99	NA	63	4	10	42.1	32.6	9.5	NA	6.0	0.4	1.0
1985	385	120	NA	48	4	5	39.5	30.6	9.5	NA	3.8	0.3	0.4
1987	400	114	NA	63	6	11	43.6	33.6	9.6	NA	5.3	0.5	0.9
1989	490	187	NA	82	12	1	46.4	35.3	13.5	NA	5.9	0.9	0.1
1991	562	234	NA	89	27	9	51.3	37.3	15.5	NA	5.9	1.8	0.6
1993	681	247	NA	92	24	14	55.6	43.3	15.7	NA	5.8	1.5	0.9
1995	719	254	NA	118	22	6	54.7	42.4	15.0	NA	7.0	1.3	0.4
FFRDCs													
1981	856	75	54	NA	15	0	40.2	35.4	3.1	2.2	NA	0.6	0.0
1983	998	131	63	NA	10	3	45.3	39.6	5.2	2.5	NA	0.4	0.1
1985	1,153	155	48	NA	17	3	44.0	38.2	5.1	1.6	NA	0.6	0.1
1987	1,301	177	63	NA	24	3	48.4	42.2	5.7	2.0	NA	0.8	0.1
1989	1,327	197	82	NA	19	5	47.9	40.9	6.1	2.5	NA	0.6	0.2
1991	1,442	259	89	NA	28	8	51.2	44.3	8.0	2.7	NA	0.9	0.2
1993	1,576	245	92	NA	31	8	57.7	50.2	7.8	2.9	NA	1.0	0.3
1995	1,762	338	118	NA	31	13	53.5	45.6	8.8	3.1	NA	0.8	0.3
Nonprofits													
1981	89	6	7	11	NA	0	44.0	35.6	2.4	2.8	4.4	NA	0.0
1983	126	19	4	10	NA	0	47.9	43.2	6.5	1.4	3.4	NA	0.0
1985	116	22	4	17	NA	3	41.9	34.9	6.6	1.2	5.1	NA	0.9
1987	124	23	6	24	NA	0	44.7	37.2	6.9	1.8	7.2	NA	0.0
1989	157	27	12	19	NA	0	49.7	42.2	7.3	3.2	5.1	NA	0.0
1991	203	38	27	28	NA	2	60.2	48.7	9.1	6.5	6.7	NA	0.5
1993	178	35	24	31	NA	1	57.8	47.2	9.3	6.4	8.2	NA	0.3
1995	204	24	22	31	NA	2	62.3	55.3	6.5	6.0	8.4	NA	0.5
Other													
1981	8	3	5	4	0	NA	38.5	20.5	7.7	12.8	10.3	0.0	NA
1983	28	14	10	3	0	NA	47.7	32.6	16.3	11.6	3.5	0.0	NA
1985	27	12	5	3	3	NA	42.9	29.7	13.2	5.5	3.3	3.3	NA
1987	22	12	11	3	0	NA	56.3	31.0	16.9	15.5	4.2	0.0	NA
1989	25	7	1	5	0	NA	49.3	37.3	10.4	1.5	7.5	0.0	NA
1991	42	17	9	8	2	NA	58.4	41.6	16.8	8.9	7.9	2.0	NA
1993	59	26	14	8	1	NA	63.6	44.7	19.7	10.6	6.1	0.8	NA
1995	44	18	6	13	2	NA	68.5	49.4	20.2	6.7	14.6	2.2	NA

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Appendix table 5-46.

Coauthorship of U.S. scientific and technical articles across sectors, by article field: 1981-95

Sector	Number of multisector articles coauthored by:						Percent of all articles coauthored by:						
	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others	All sectors	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others
Earth and space sciences													
Academia													
1981	NA	207	560	357	174	57	21.5	NA	3.7	10.0	6.4	3.1	1.0
1983	NA	222	530	320	187	81	22.2	NA	4.2	10.0	6.0	3.5	1.5
1985	NA	286	604	363	217	98	23.4	NA	4.9	10.3	6.2	3.7	1.7
1987	NA	311	645	411	250	115	24.6	NA	5.0	10.5	6.7	4.1	1.9
1989	NA	336	628	401	346	113	24.9	NA	5.4	10.1	6.5	5.6	1.8
1991	NA	351	764	474	405	126	27.3	NA	5.3	11.5	7.1	6.1	1.9
1993	NA	380	892	523	416	129	27.0	NA	5.2	12.2	7.2	5.7	1.8
1995	NA	467	1,108	652	512	158	29.4	NA	5.7	13.5	7.9	6.2	1.9
Industry													
1981	207	NA	127	34	17	11	51.0	34.2	NA	21.0	5.6	2.8	1.8
1983	222	NA	139	31	18	20	53.2	33.4	NA	20.9	4.7	2.7	3.0
1985	286	NA	173	36	35	33	52.2	32.7	NA	19.8	4.1	4.0	3.8
1987	311	NA	198	68	32	38	55.7	34.3	NA	21.8	7.5	3.5	4.2
1989	336	NA	203	55	46	52	57.7	37.5	NA	22.7	6.1	5.1	5.8
1991	351	NA	198	53	45	37	55.4	37.1	NA	20.9	5.6	4.8	3.9
1993	380	NA	255	61	47	44	65.2	42.4	NA	28.4	6.8	5.2	4.9
1995	467	NA	296	110	64	41	68.4	44.7	NA	28.4	10.5	6.1	3.9
Federal Government													
1981	560	127	NA	88	46	19	44.1	34.7	7.9	NA	5.5	2.9	1.2
1983	530	139	NA	78	42	21	44.9	34.5	9.0	NA	5.1	2.7	1.4
1985	604	173	NA	89	67	24	47.6	35.2	10.1	NA	5.2	3.9	1.4
1987	645	198	NA	105	71	40	50.9	37.0	11.4	NA	6.0	4.1	2.3
1989	628	203	NA	132	82	41	51.9	37.4	12.1	NA	7.9	4.9	2.4
1991	764	198	NA	129	100	38	53.8	41.6	10.8	NA	7.0	5.4	2.1
1993	892	255	NA	157	110	50	57.8	44.9	12.8	NA	7.9	5.5	2.5
1995	1,108	296	NA	207	148	48	62.3	48.5	13.0	NA	9.1	6.5	2.1
FFRDCs													
1981	357	34	88	NA	19	6	50.4	42.5	4.0	10.5	NA	2.3	0.7
1983	320	31	78	NA	28	15	49.6	40.2	3.9	9.8	NA	3.5	1.9
1985	363	36	89	NA	33	3	52.3	43.2	4.3	10.6	NA	3.9	0.4
1987	411	68	105	NA	39	8	55.3	43.2	7.2	11.0	NA	4.1	0.8
1989	401	55	132	NA	76	9	57.6	44.2	6.1	14.5	NA	8.4	1.0
1991	474	53	129	NA	65	7	59.3	47.9	5.4	13.0	NA	6.6	0.7
1993	523	61	157	NA	74	16	60.8	50.4	5.9	15.1	NA	7.1	1.5
1995	652	110	207	NA	98	21	60.1	48.0	8.1	15.3	NA	7.2	1.5

Appendix table 5-46.

Coauthorship of U.S. scientific and technical articles across sectors, by article field: 1981-95

Sector	Number of multisector articles coauthored by:						Percent of all articles coauthored by:						
	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others	All sectors	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others
Nonprofits													
1981	174	17	46	19	NA	3	46.3	38.6	3.8	10.2	4.2	NA	0.7
1983	187	18	42	28	NA	6	46.0	37.6	3.6	8.4	5.6	NA	1.2
1985	217	35	67	33	NA	6	48.3	37.9	6.1	11.7	5.8	NA	1.0
1987	250	32	71	39	NA	5	57.6	45.5	5.8	12.9	7.1	NA	0.9
1989	346	46	82	76	NA	19	57.3	45.3	6.0	10.7	9.9	NA	2.5
1991	405	45	100	65	NA	17	56.9	47.1	5.2	11.6	7.6	NA	2.0
1993	416	47	110	74	NA	21	60.0	48.8	5.5	12.9	8.7	NA	2.5
1995	512	64	148	98	NA	12	63.7	52.5	6.6	15.2	10.0	NA	1.2
Other													
1981	57	11	19	6	3	NA	51.0	39.3	7.6	13.1	4.1	2.1	NA
1983	81	20	21	15	6	NA	62.2	47.1	11.6	12.2	8.7	3.5	NA
1985	98	33	24	3	6	NA	53.2	37.3	12.5	9.1	1.1	2.3	NA
1987	115	38	40	8	5	NA	62.3	43.4	14.3	15.1	3.0	1.9	NA
1989	113	52	41	9	19	NA	64.1	39.4	18.1	14.3	3.1	6.6	NA
1991	126	37	38	7	17	NA	58.2	42.1	12.4	12.7	2.3	5.7	NA
1993	129	44	50	16	21	NA	65.8	44.2	15.1	17.1	5.5	7.2	NA
1995	158	41	48	21	12	NA	70.0	52.7	13.7	16.0	7.0	4.0	NA
Engineering and technology													
Academia													
1981	NA	746	260	259	67	69	20.1	NA	11.5	4.0	4.0	1.0	1.1
1983	NA	811	311	275	59	62	20.3	NA	11.6	4.5	3.9	0.8	0.9
1985	NA	645	273	256	51	36	18.4	NA	10.2	4.3	4.0	0.8	0.6
1987	NA	617	283	241	59	48	18.5	NA	10.0	4.6	3.9	1.0	0.8
1989	NA	644	277	278	61	30	18.1	NA	9.7	4.2	4.2	0.9	0.5
1991	NA	810	333	282	65	46	20.1	NA	11.4	4.7	4.0	0.9	0.6
1993	NA	818	382	297	68	80	20.4	NA	11.0	5.2	4.0	0.9	1.1
1995	NA	968	443	321	66	46	21.3	NA	12.4	5.7	4.1	0.8	0.6
Industry													
1981	746	NA	159	89	41	53	20.7	15.6	NA	3.3	1.9	0.9	1.1
1983	811	NA	188	118	39	50	21.8	16.0	NA	3.7	2.3	0.8	1.0
1985	645	NA	123	112	59	32	24.3	17.9	NA	3.4	3.1	1.6	0.9
1987	617	NA	121	64	31	16	29.0	23.4	NA	4.6	2.4	1.2	0.6
1989	644	NA	122	73	35	18	29.7	23.3	NA	4.4	2.6	1.3	0.7
1991	810	NA	137	80	36	26	32.3	26.3	NA	4.4	2.6	1.2	0.8
1993	818	NA	179	89	37	48	36.7	28.2	NA	6.2	3.1	1.3	1.7
1995	968	NA	231	123	41	35	40.7	32.2	NA	7.7	4.1	1.4	1.2

Appendix table 5-46.

Coauthorship of U.S. scientific and technical articles across sectors, by article field: 1981-95

Sector	Number of multisector articles coauthored by:						Percent of all articles coauthored by:						
	Academia	Industry	Federal Govt	FFRDCs	Nonprofits	All others	All sectors	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others
Federal Government													
1981	260	159	NA	33	14	21	34.1	20.7	12.7	NA	2.6	1.1	1.7
1983	311	188	NA	42	14	12	36.6	22.9	13.8	NA	3.1	1.0	0.9
1985	273	123	NA	39	24	10	37.9	25.1	11.3	NA	3.6	2.2	0.9
1987	283	121	NA	27	10	7	45.2	32.6	14.0	NA	3.1	1.2	0.8
1989	277	122	NA	35	10	5	43.9	30.3	13.4	NA	3.8	1.1	0.5
1991	333	137	NA	14	12	6	44.4	33.4	13.8	NA	1.4	1.2	0.6
1993	382	179	NA	32	29	17	52.0	35.6	16.7	NA	3.0	2.7	1.6
1995	443	231	NA	44	19	9	53.8	38.5	20.1	NA	3.8	1.6	0.8
FFRDCs													
1981	259	89	33	NA	6	3	24.6	18.0	6.2	2.3	NA	0.4	0.2
1983	275	118	42	NA	6	5	29.2	18.1	7.8	2.8	NA	0.4	0.3
1985	256	112	39	NA	8	4	29.4	18.2	8.0	2.8	NA	0.6	0.3
1987	241	64	27	NA	7	6	28.8	21.1	5.6	2.4	NA	0.6	0.5
1989	278	73	35	NA	10	3	39.8	28.7	7.5	3.6	NA	1.0	0.3
1991	282	80	14	NA	11	2	44.1	31.9	9.0	1.6	NA	1.2	0.2
1993	297	89	32	NA	13	5	46.1	33.4	10.0	3.6	NA	1.5	0.6
1995	321	123	44	NA	22	7	47.5	33.0	12.6	4.5	NA	2.3	0.7
Nonprofits													
1981	67	41	14	6	NA	6	32.2	19.3	11.8	4.0	1.7	NA	1.7
1983	59	39	14	6	NA	5	32.2	17.8	11.7	4.2	1.8	NA	1.5
1985	51	59	24	8	NA	3	42.0	19.0	21.9	8.9	3.0	NA	1.1
1987	59	31	10	7	NA	0	40.9	28.4	14.9	4.8	3.4	NA	0.0
1989	61	35	10	10	NA	1	42.5	26.2	15.0	4.3	4.3	NA	0.4
1991	65	36	12	11	NA	2	46.8	29.5	16.4	5.5	5.0	NA	0.9
1993	68	37	29	13	NA	6	53.8	28.6	15.5	12.2	5.5	NA	2.5
1995	66	41	19	22	NA	4	53.3	30.8	19.2	8.9	10.3	NA	1.9
Other													
1981	69	53	21	3	6	NA	41.2	22.9	17.6	7.0	1.0	2.0	NA
1983	62	50	12	5	5	NA	52.0	27.6	22.2	5.3	2.2	2.2	NA
1985	36	32	10	4	3	NA	51.4	25.0	22.2	6.9	2.8	2.1	NA
1987	48	16	7	6	0	NA	60.2	46.6	15.5	6.8	5.8	0.0	NA
1989	30	18	5	3	1	NA	50.5	31.6	18.9	5.3	3.2	1.1	NA
1991	46	26	6	2	2	NA	46.6	31.1	17.6	4.1	1.4	1.4	NA
1993	80	48	17	5	6	NA	62.0	37.6	22.5	8.0	2.3	2.8	NA
1995	46	35	9	7	4	NA	61.9	33.1	25.2	6.5	5.0	2.9	NA

Appendix table 5-46.

Coauthorship of U.S. scientific and technical articles across sectors, by article field: 1981-95

Sector	Number of multisector articles coauthored by:						Percent of all articles coauthored by:						
	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others	All sectors	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others
							Mathematics						
Academia													
1981	NA	89	36	36	45	9	5.4	NA	2.3	0.9	0.9	1.1	0.2
1983	NA	100	42	25	55	6	6.0	NA	2.7	1.1	0.7	1.5	0.2
1985	NA	105	57	35	38	5	6.4	NA	2.8	1.5	0.9	1.0	0.1
1987	NA	80	35	38	42	1	6.3	NA	2.7	1.2	1.3	1.4	0.0
1989	NA	97	36	30	36	7	5.1	NA	2.5	0.9	0.8	0.9	0.2
1991	NA	76	43	33	38	12	6.0	NA	2.3	1.3	1.0	1.2	0.4
1993	NA	114	53	34	44	9	7.2	NA	3.4	1.6	1.0	1.3	0.3
1995	NA	79	37	26	47	10	6.2	NA	2.6	1.2	0.9	1.5	0.3
Industry													
1981	89	NA	3	0	1	0	44.2	42.8	NA	1.4	0.0	0.5	0.0
1983	100	NA	2	6	2	1	45.1	42.6	NA	0.9	2.6	0.9	0.4
1985	105	NA	5	2	0	0	44.5	42.9	NA	2.0	0.8	0.0	0.0
1987	80	NA	9	3	5	0	47.4	42.1	NA	4.7	1.6	2.6	0.0
1989	97	NA	6	2	3	2	54.2	51.1	NA	3.2	1.1	1.6	1.1
1991	76	NA	6	1	1	1	52.3	49.0	NA	3.9	0.6	0.6	0.6
1993	114	NA	9	2	5	2	61.2	56.7	NA	4.5	1.0	2.5	1.0
1995	79	NA	3	1	4	1	58.3	56.8	NA	2.2	0.7	2.9	0.7
Federal Government													
1981	36	3	NA	1	1	0	35.1	32.4	2.7	NA	0.9	0.9	0.0
1983	42	2	NA	0	1	0	50.0	47.7	2.3	NA	0.0	1.1	0.0
1985	57	5	NA	0	0	1	41.8	39.0	3.4	NA	0.0	0.0	0.7
1987	35	9	NA	0	3	0	42.1	36.8	9.5	NA	0.0	3.2	0.0
1989	36	6	NA	1	3	0	45.7	39.1	6.5	NA	1.1	3.3	0.0
1991	43	6	NA	1	2	1	53.8	46.2	6.5	NA	1.1	2.2	1.1
1993	53	9	NA	0	3	2	54.9	46.9	8.0	NA	0.0	2.7	1.8
1995	37	3	NA	1	2	0	51.4	50.0	4.1	NA	1.4	2.7	0.0
FFRDCs													
1981	36	0	1	NA	0	1	49.4	46.8	0.0	1.3	NA	0.0	1.3
1983	25	6	0	NA	0	0	44.8	37.3	9.0	0.0	NA	0.0	0.0
1985	35	2	0	NA	1	0	56.3	54.7	3.1	0.0	NA	1.6	0.0
1987	38	3	0	NA	1	0	54.4	48.1	3.8	0.0	NA	1.3	0.0
1989	30	2	1	NA	0	0	48.1	39.0	2.6	1.3	NA	0.0	0.0
1991	33	1	1	NA	1	0	52.2	47.8	1.4	1.4	NA	1.4	0.0
1993	34	2	0	NA	0	0	51.5	50.0	2.9	0.0	NA	0.0	0.0
1995	26	1	1	NA	0	0	57.4	55.3	2.1	2.1	NA	0.0	0.0

Appendix table 5-46.

Coauthorship of U.S. scientific and technical articles across sectors, by article field: 1981-95

Sector	Number of multisector articles coauthored by:						Percent of all articles coauthored by:						
	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others	All sectors	Academia	Industry	Federal Govt.	FFRDCs	Nonprofits	All others
Nonprofits													
1981	45	1	1	1	NA	1	50.5	49.5	1.1	1.1	1.1	NA	1.1
1983	55	2	1	0	NA	0	56.1	56.1	2.0	1.0	0.0	NA	0.0
1985	38	0	0	1	NA	0	43.3	42.2	0.0	0.0	1.1	NA	0.0
1987	42	5	3	1	NA	0	47.8	45.7	5.4	3.3	1.1	NA	0.0
1989	36	3	3	0	NA	2	59.1	54.5	4.5	4.5	0.0	NA	3.0
1991	38	1	2	1	NA	0	51.3	47.5	1.3	2.5	1.3	NA	0.0
1993	44	5	3	0	NA	0	58.2	55.7	6.3	3.8	0.0	NA	0.0
1995	47	4	2	0	NA	1	65.3	62.7	5.3	2.7	0.0	NA	1.3
Other													
1981	9	0	0	0	1	NA	58.8	52.9	0.0	0.0	0.0	5.9	NA
1983	6	1	0	0	0	NA	77.8	66.7	11.1	0.0	0.0	0.0	NA
1985	5	0	1	0	0	NA	35.7	35.7	0.0	7.1	0.0	0.0	NA
1987	1	0	0	0	0	NA	16.7	16.7	0.0	0.0	0.0	0.0	NA
1989	7	2	0	0	2	NA	47.4	36.8	10.5	0.0	0.0	10.5	NA
1991	12	1	1	0	0	NA	60.0	60.0	5.0	5.0	0.0	0.0	NA
1993	9	2	2	0	0	NA	73.3	60.0	13.3	13.3	0.0	0.0	NA
1995	10	1	0	0	1	NA	80.0	66.7	6.7	0.0	0.0	6.7	NA

FFRDC = federally funded research and development center; NA = not available

NOTES: Cross-sector percentages add to more than percentage coauthored with all sectors because of papers with authors in more than two sectors. Coauthored articles are counted in each collaborating sector. Details may not add to totals because of rounding.

SOURCES: Institute for Scientific Information, Science Citation Index; CHI Research Inc., Science Indicators database; and National Science Foundation, unpublished tabulations.

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Science & Engineering Indicators – 1998

Appendix table 5-47.

Distribution of citations in U.S. scientific and technical articles to other U.S. scientific and technical articles, by sector and field: 1990 and 1995

Citing sector	Citing year	Number of citations to: All sectors	Academia	Industry	Federal Govt.	FFRDCs	Non-profits	Others	Percent of citations to: Academia	Industry	Federal Govt.	FFRDCs	Non-profits	Others
All natural science and engineering fields														
Academic	1990	440,334	335,353	25,252	34,940	6,440	33,321	5,028	76	6	8	1	8	1
	1995	443,191	341,017	26,165	30,500	6,126	34,908	4,474	77	6	7	1	8	1
Industry	1990	41,586	19,270	15,353	3,369	750	2,352	491	46	37	8	2	6	1
	1995	39,085	19,628	12,744	2,929	551	2,827	407	50	33	7	1	7	1
Federal Government	1990	54,570	28,157	3,439	17,462	683	4,030	800	52	6	32	1	7	1
	1995	49,271	26,717	3,139	14,409	673	3,638	693	54	6	29	1	7	1
FFRDCs	1990	10,114	4,955	1,116	547	3,203	269	24	49	11	5	32	3	0
	1995	10,658	5,766	822	771	2,947	313	38	54	8	7	28	3	0
Nonprofits	1990	50,298	29,677	2,523	4,533	338	12,285	941	59	5	9	1	24	2
	1995	52,378	31,645	2,738	3,792	280	13,110	813	60	5	7	1	25	2
All other	1990	7,800	4,605	406	934	65	825	965	59	5	12	1	11	12
	1995	6,814	4,111	410	757	35	787	714	60	6	11	1	12	10
Clinical medicine														
Academic	1990	159,444	116,645	5,212	15,584	234	18,350	3,419	73	3	10	0	12	2
	1995	151,621	110,581	7,347	12,834	202	17,720	2,937	73	5	8	0	12	2
Industry	1990	11,098	5,588	2,866	1,223	15	1,107	297	50	26	11	0	10	3
	1995	12,630	6,285	3,729	1,051	15	1,339	211	50	30	8	0	11	2
Federal Government	1990	22,246	11,749	917	6,767	34	2,243	537	53	4	30	0	10	2
	1995	18,819	10,241	977	5,195	33	1,938	437	54	5	28	0	10	2
FFRDCs	1990	495	288	22	52	73	52	7	58	4	11	15	11	1
	1995	457	281	22	40	75	36	4	61	5	9	16	8	1
Nonprofits	1990	28,340	16,566	927	2,667	36	7,411	733	58	3	9	0	26	3
	1995	28,254	16,465	1,274	2,233	28	7,609	645	58	5	8	0	27	2
All other	1990	4,945	2,956	179	597	5	636	574	60	4	12	0	13	12
	1995	4,222	2,549	182	457	2	591	442	60	4	11	0	14	10
Biomedical research														
Academic	1990	155,167	119,366	8,665	12,384	993	12,661	1,097	77	6	8	1	8	1
	1995	164,284	129,210	8,782	10,201	968	14,225	898	79	5	6	1	9	1
Industry	1990	11,400	5,970	3,066	1,151	94	1,002	118	52	27	10	1	9	1
	1995	13,357	7,435	3,504	957	85	1,264	112	56	26	7	1	9	1
Federal Government	1990	18,755	10,049	1,328	5,581	136	1,525	136	54	7	30	1	8	1
	1995	16,847	9,863	1,052	4,333	111	1,372	116	59	6	26	1	8	1
FFRDCs	1990	1,336	784	105	87	284	73	2	59	8	7	21	5	0
	1995	1,552	997	106	109	248	87	6	64	7	7	16	6	0
Nonprofits	1990	17,787	10,619	1,295	1,566	106	4,026	175	60	7	9	1	23	1
	1995	19,663	12,448	1,244	1,234	95	4,513	129	63	6	6	0	23	1
All other	1990	1,800	1,055	126	202	20	149	249	59	7	11	1	8	14
	1995	1,743	1,086	132	188	11	159	166	62	8	11	1	9	10

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Appendix table 5-47.

Distribution of citations in U.S. scientific and technical articles to other U.S. scientific and technical articles, by sector and field: 1990 and 1995

		Number of citations to:							Percent of citations to:					
Citing sector	Citing year	All sectors	Academia	Industry	Federal Govt.	FFRDCs	Non-profits	Others	Academia	Industry	Federal Govt.	FFRDCs	Non-profits	Others
							Biology							
Academic	1990	24,010	20,558	526	2,046	44	593	244	86	2	9	0	2	1
	1995	19,740	16,481	532	1,849	47	578	253	83	3	9	0	3	1
Industry	1990	856	543	178	99	1	27	8	63	21	12	0	3	1
	1995	866	519	192	115	3	27	10	60	22	13	0	3	1
Federal Government	1990	4,034	2,014	95	1,789	5	73	59	50	2	44	0	2	1
	1995	3,620	1,843	90	1,526	9	92	61	51	2	42	0	3	2
FFRDCs	1990	65	47	2	5	9	2	0	72	3	8	14	3	0
	1995	120	79	3	18	14	5	2	66	3	15	12	4	2
Nonprofits	1990	926	605	19	63	2	223	15	65	2	7	0	24	2
	1995	847	542	21	85	3	180	17	64	2	10	0	21	2
All other	1990	406	252	11	65	1	14	63	62	3	16	0	3	16
	1995	334	209	10	50	0	15	50	63	3	15	0	4	15
							Chemistry							
Academic	1990	32,470	27,910	2,597	896	745	262	59	86	8	3	2	1	0
	1995	33,822	28,892	2,907	856	632	459	75	85	9	3	2	1	0
Industry	1990	4,845	2,350	2,127	205	77	77	9	49	44	4	2	2	0
	1995	3,986	1,891	1,766	179	56	76	18	47	44	4	1	2	0
Federal Government	1990	1,553	679	200	609	35	24	7	44	13	39	2	2	0
	1995	1,516	688	180	580	24	31	13	45	12	38	2	2	1
FFRDCs	1990	923	486	81	27	323	5	0	53	9	3	35	1	0
	1995	953	571	74	32	269	7	1	60	8	3	28	1	0
Nonprofits	1990	439	233	71	28	8	96	2	53	16	6	2	22	0
	1995	851	467	89	29	10	252	4	55	10	3	1	30	0
All other	1990	132	80	17	13	3	4	17	61	13	10	2	3	13
	1995	116	50	28	21	3	5	9	43	24	18	3	4	8
							Physics							
Academic	1990	38,039	27,217	6,001	1,368	2,912	489	53	72	16	4	8	1	0
	1995	38,027	28,951	4,444	1,511	2,616	446	58	76	12	4	7	1	0
Industry	1990	9,524	3,209	5,473	329	429	60	24	34	57	3	5	1	0
	1995	4,941	2,012	2,377	242	241	51	18	41	48	5	5	1	0
Federal Government	1990	3,066	1,261	578	976	198	34	17	41	19	32	6	1	1
	1995	2,801	1,328	405	887	134	38	9	47	14	32	5	1	0
FFRDCs	1990	4,959	2,206	761	152	1,773	60	7	44	15	3	36	1	0
	1995	4,339	2,159	444	160	1,527	42	7	50	10	4	35	1	0
Nonprofits	1990	764	383	125	46	53	150	7	50	16	6	7	20	1
	1995	551	333	40	29	46	103	1	60	7	5	8	19	0
All other	1990	110	46	25	9	22	4	3	42	23	8	20	4	3
	1995	81	42	20	7	5	2	5	52	25	9	6	2	6

Appendix table 5-47.

Distribution of citations in U.S. scientific and technical articles to other U.S. scientific and technical articles, by sector and field: 1990 and 1995

Citing sector	Citing year	Number of citations to: All sectors	Academia	Industry	Federal Govt.	FFRDCs	Non-profits	Others	Percent of citations to: Academia	Industry	Federal Govt.	FFRDCs	Non-profits	Others
Earth and space sciences														
Academic	1990	18,852	13,756	784	2,179	1,178	821	134	73	4	12	6	4	1
	1995	23,977	17,420	885	2,703	1,421	1,332	216	73	4	11	6	6	1
Industry	1990	1,247	610	286	214	70	43	25	49	23	17	6	3	2
	1995	1,367	638	278	279	103	44	26	47	20	20	8	3	2
Federal Government	1990	3,918	1,972	186	1,348	249	120	43	50	5	34	6	3	1
	1995	4,595	2,301	274	1,484	333	150	53	50	6	32	7	3	1
FFRDCs	1990	1,795	934	74	200	508	72	6	52	4	11	28	4	0
	1995	2,765	1,481	105	379	654	127	18	54	4	14	24	5	1
Nonprofits	1990	1,795	1,133	55	150	122	327	8	63	3	8	7	18	0
	1995	2,014	1,283	45	169	94	408	14	64	2	8	5	20	1
All other	1990	300	157	23	44	11	14	52	52	8	15	4	5	17
	1995	262	146	24	31	12	12	36	56	9	12	5	5	14
Engineering & technology														
Academic	1990	9,295	7,104	1,348	433	291	98	22	76	15	5	3	1	0
	1995	9,115	7,071	1,194	506	214	102	28	78	13	6	2	1	0
Industry	1990	2,490	925	1,319	143	59	35	10	37	53	6	2	1	0
	1995	1,831	774	871	103	46	23	12	42	48	6	3	1	1
Federal Government	1990	869	343	127	366	24	7	1	39	15	42	3	1	0
	1995	997	407	159	384	28	16	4	41	16	39	3	2	0
FFRDCs	1990	486	169	67	25	219	5	1	35	14	5	45	1	0
	1995	433	175	67	31	151	9	1	40	15	7	35	2	0
Nonprofits	1990	184	87	30	11	11	44	2	47	16	6	6	24	1
	1995	131	57	24	11	4	33	2	44	18	8	3	25	2
All other	1990	80	42	24	6	1	3	5	53	30	8	1	4	6
	1995	43	22	13	4	1	0	3	51	30	9	2	0	7

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Appendix table 5-47.
Distribution of citations in U.S. scientific and technical articles to other U.S. scientific and technical articles, by sector and field: 1990 and 1995

Citing sector	Citing year	Number of citations to: All sectors	Academia	Industry	Federal Govt.	FFRDCs	Non-profits	Others	Percent of citations to: Academia	Industry	Federal Govt.	FFRDCs	Non-profits	Others
Mathematics														
Academic	1990	3,056	2,797	119	49	43	47	1	92	4	2	1	2	0
	1995	2,606	2,411	76	41	25	46	7	93	3	2	1	2	0
Industry	1990	126	76	37	6	5	1	1	60	29	5	4	1	1
	1995	107	74	27	2	1	3	0	69	25	2	1	3	0
Federal Government	1990	130	89	8	26	2	4	0	68	6	20	2	3	0
	1995	75	46	4	22	1	1	1	61	5	29	1	1	1
FFRDCs	1990	56	40	3	0	12	1	0	71	5	0	21	2	0
	1995	39	24	2	3	9	1	0	62	5	8	23	3	0
Nonprofits	1990	62	50	2	2	0	8	0	81	3	3	0	13	0
	1995	68	50	3	3	0	11	1	74	4	4	0	16	1
All other	1990	27	20	1	1	0	1	3	74	4	4	0	4	11
	1995	12	9	1	0	0	1	1	75	8	0	0	8	8

FFRDC = federally funded research and development center

NOTE: Details may not add to totals because of rounding.

SOURCES: Institute for Scientific Information, Science Citation Index; CHI Research Inc., Science Indicators database; and National Science Foundation, unpublished tabulations.

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Appendix table 5-48.

Distribution of citations in U.S. scientific and technical articles across broad and fine fields: 1994-95

		Percentage of cited articles in:								
Broad/fine field of citing article	Number of cited articles	Same fine field	Clinical medicine	Biomedical research	Biology	Chemistry	Physics	Earth & space sciences	Engineering & technology	Mathe-matics
				Broad field						
Clinical medicine	920,375	NA	73	26	1	0	0	0	0	0
Biomedical research	651,297	NA	17	77	2	2	1	1	0	0
Biology	106,508	NA	6	27	62	1	0	4	0	0
Chemistry	196,606	NA	3	11	1	69	12	2	2	0
Physics	246,357	NA	1	4	0	7	83	2	4	0
Earth & space science	114,848	NA	1	8	3	1	3	83	1	0
Engineering & technology	53,137	NA	1	2	1	8	20	3	64	2
Mathematics	9,960	NA	2	2	0	0	8	1	9	79
				Clinical medicine						
Addictive diseases	4,750	30	85	14	1	0	0	0	0	0
Allergy	4,251	21	80	19	1	0	0	0	0	0
Anesthesiology	8,799	47	90	9	1	0	0	0	0	0
Arthritis & rheumatism	9,337	33	84	16	1	0	0	0	0	0
Cancer	72,060	39	69	30	1	0	0	0	0	0
Cardiovascular system	57,970	50	78	21	1	0	0	0	0	0
Dentistry	7,461	60	86	13	1	0	0	0	0	0
Dermatology & venereal disease	13,238	34	74	25	1	0	0	0	0	0
Endocrinology	44,651	33	61	38	1	0	0	0	0	0
Fertility	8,012	30	69	26	5	0	0	0	0	0
Gastroenterology	21,768	32	75	24	1	0	0	0	0	0
General & internal medicine	75,753	25	77	22	1	0	0	0	0	0
Geriatrics	5,381	24	79	21	1	0	0	0	0	0
Hematology	30,550	30	64	35	0	0	0	0	0	0
Hygiene & public health	11,701	30	78	13	3	1	0	4	0	1
Immunology	121,214	44	63	36	1	0	0	0	0	0
Miscellaneous clinical medicine	2,940	27	73	26	0	0	0	0	0	0
Nephrology	11,308	24	64	35	1	0	0	0	0	0
Neurology, neurosurgery	125,305	51	69	30	1	0	0	0	0	0
Obstetrics, gynecology	12,713	44	88	11	0	0	0	0	0	0
Ophthalmology	13,023	59	79	20	0	0	0	0	0	0
Orthopedics	4,361	63	87	13	0	0	0	0	0	0
Otorhinolaryngology	7,687	51	87	9	0	0	4	0	0	0
Pathology	20,835	21	70	30	1	0	0	0	0	0
Pediatrics	15,042	28	82	17	0	0	0	0	0	0
Pharmacology	92,961	31	67	30	1	2	0	0	0	0
Pharmacy	4,346	14	71	15	1	12	0	0	0	0
Psychiatry	13,391	67	95	5	0	0	0	0	0	0
Radiology & nuclear medicine	29,328	57	90	7	0	1	1	0	1	0

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Appendix table 5-48.

Distribution of citations in U.S. scientific and technical articles across broad and fine fields: 1994-95

Broad/fine field of citing article	Number of cited articles	Percentage of cited articles in:								
		Same fine field	Clinical medicine	Biomedical research	Biology	Chemistry	Physics	Earth & space sciences	Engineering & technology	Mathe-matics
Respiratory system	14,250	28	82	18	0	0	0	0	0	0
Surgery	30,428	49	90	9	0	0	0	0	0	0
Tropical medicine	1,747	17	60	32	6	0	0	0	0	0
Urology	12,299	49	91	9	0	0	0	0	0	0
Veterinary medicine	11,581	42	71	22	7	0	0	0	0	0
Biomedical research										
Anatomy & morphology	3,833	9	30	65	5	0	0	0	0	0
Biochemistry & molecular biology	300,619	50	13	83	2	2	0	0	0	0
Biomedical engineering	8,153	23	24	60	3	7	1	2	3	0
Biophysics	8,934	14	10	78	1	6	4	0	0	0
Cell biology, cytology & histology	54,087	21	21	77	2	0	0	0	0	0
Embryology	8,718	19	15	84	1	0	0	0	0	0
General biomedical research	73,897	27	22	66	4	2	2	3	0	0
Genetics & heredity	40,393	29	13	81	6	0	0	0	0	0
Microbiology	41,026	43	15	78	4	1	0	1	0	0
Microscopy	2,813	15	26	49	2	3	16	0	3	0
Miscellaneous biomedical research	5,179	17	43	50	2	2	1	1	1	1
Nutrition & dietetics	11,477	30	39	55	6	1	0	0	0	0
Parasitology	5,283	28	23	70	7	0	0	0	0	0
Physiology	48,332	33	35	62	2	0	0	0	0	0
Virology	38,594	47	14	85	1	0	0	0	0	0
Biology										
Agriculture & food science	17,844	51	5	17	68	4	0	5	1	0
Botany	35,776	50	1	35	61	2	0	1	0	0
Dairy & animal science	8,423	61	18	14	67	0	0	0	0	0
Ecology	9,726	48	1	17	77	0	0	4	0	0
Entomology	8,719	57	4	23	71	1	0	0	0	0
General biology	5,606	7	21	62	16	1	0	1	0	0
General zoology	4,665	14	14	38	46	0	0	2	0	0
Marine biology & hydro-biology	10,885	47	3	14	65	0	0	18	0	0
Miscellaneous biology	2,140	32	12	31	47	0	0	7	0	1
Miscellaneous zoology	2,730	37	5	20	73	0	0	1	0	0
Chemistry										
Analytical chemistry	26,073	55	8	12	3	67	5	4	1	0
Applied chemistry	1,656	21	5	19	9	52	3	4	7	0
General chemistry	56,053	36	3	17	2	65	10	2	1	0
Inorganic & nuclear chemistry	15,935	35	1	7	0	88	3	0	1	0
Organic chemistry	34,697	41	5	8	2	84	1	0	0	0
Physical chemistry	45,934	36	1	9	0	55	30	2	4	0
Polymers	16,263	64	0	4	0	79	13	0	4	0

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Appendix table 5-48.

Distribution of citations in U.S. scientific and technical articles across broad and fine fields: 1994-95

Broad/fine field of citing article	Number of cited articles	Percentage of cited articles in: Same fine field	Clinical medicine	Biomedical research	Biology	Chemistry	Physics	Earth & space sciences	Engineering & technology	Mathematics
Physics										
Acoustics	3,562	62	9	2	0	0	68	2	16	2
Applied physics	51,328	53	0	3	0	6	82	1	8	0
Chemical physics	41,267	46	1	7	0	22	68	1	1	0
Fluids & plasmas	7,309	55	0	1	0	3	81	6	8	1
General physics	58,507	48	0	4	0	3	86	3	2	1
Miscellaneous physics	721	28	0	0	0	1	70	4	6	18
Nuclear & particle physics	32,739	68	0	1	0	1	94	3	0	0
Optics	15,811	50	2	3	1	2	80	3	9	0
Solid state physics	35,151	40	0	5	0	4	88	0	2	0
Earth and space sciences										
Astronomy & astrophysics	37,421	89	0	4	0	0	4	92	0	0
Earth & planetary science	34,862	64	0	10	1	1	3	84	1	0
Environmental science	14,975	51	8	12	12	6	1	60	2	0
Geology	10,617	53	0	8	2	2	2	85	1	0
Meteorology & atmospheric science	10,049	61	0	8	2	2	4	83	2	0
Oceanography & limnology	6,923	59	0	9	13	1	3	73	1	0
Engineering and technology										
Aerospace technology	1,951	60	0	0	0	1	17	2	77	3
Chemical engineering	5,233	42	1	6	1	29	11	3	49	0
Civil engineering	1,238	48	0	2	5	2	3	25	61	2
Computers	4,350	66	3	4	0	2	8	0	77	6
Electrical engineering & electronics	12,153	56	1	2	0	3	27	2	63	3
General engineering	360	13	0	0	0	2	38	4	48	7
Industrial engineering	65	29	0	2	0	0	0	0	92	6
Library & information science	11	27	55	9	0	9	0	0	27	0
Materials science	11,617	40	0	3	1	10	28	1	58	0
Mechanical engineering	5,607	54	0	1	0	4	16	2	73	3
Metals & metallurgy	6,215	52	0	1	0	8	18	0	73	0
Misc. engineering & technology	1,273	29	1	4	7	4	12	21	49	2
Nuclear technology	2,656	56	7	2	0	2	23	1	65	0
Operations research & mgmt science	417	59	1	1	0	0	0	2	76	18
Mathematics										
Applied mathematics	3,458	56	1	2	0	1	13	2	18	64
General mathematics	4,143	78	0	1	0	0	6	0	3	90
Miscellaneous mathematics	260	37	0	0	0	0	5	0	7	87
Probability & statistics	2,098	77	7	4	1	0	2	1	5	80

NA = not available

NOTE: Citation counts are from U.S. articles published in 1994 and 1995 to U.S. output published in 1990 through 1993, based on the 1985 Science Citation Index journals set. Details may not add to totals because of rounding.

SOURCES: Institute for Scientific Information, Science Citation Index; CHI Research Inc., Science Indicators database; and National Science Foundation, unpublished tabulations.

Appendix table 5-49.

Scientific and technical articles, by country and field: 1981-95, selected years

Region/country	Number of scientific & technical articles published in:					Percent of total scientific & technical articles published in:				
	1981	1985	1989	1992	1995	1981	1985	1989	1992	1995
	All natural science and engineering fields									
World	368,934	389,846	403,845	425,346	438,767	100.0	100.0	100.0	100.0	100.0
United States	132,278	137,771	140,833	143,174	142,792	35.9	35.3	34.9	33.7	32.5
Canada	14,440	16,656	17,232	17,958	17,359	3.9	4.3	4.3	4.2	4.0
United Kingdom	30,794	32,256	30,571	31,806	32,980	8.3	8.3	7.6	7.5	7.5
France	18,567	18,422	19,754	21,548	23,811	5.0	4.7	4.9	5.1	5.4
Germany	26,837	27,310	27,353	29,169	30,654	7.3	7.0	6.8	6.9	7.0
Austria	2,160	2,179	2,315	2,522	2,807	0.6	0.6	0.6	0.6	0.6
Belgium	3,309	3,424	3,233	3,488	3,996	0.9	0.9	0.8	0.8	0.9
Ireland	700	653	665	708	900	0.2	0.2	0.2	0.2	0.2
Luxembourg	13	12	6	15	20	0.0	0.0	0.0	0.0	0.0
Netherlands	5,993	7,079	8,017	8,492	9,239	1.6	1.8	2.0	2.0	2.1
Switzerland	4,801	4,895	4,783	5,423	5,896	1.3	1.3	1.2	1.3	1.3
Other W. Europe	10	5	5	5	9	0.0	0.0	0.0	0.0	0.0
Italy	7,803	9,377	10,720	12,351	14,117	2.1	2.4	2.7	2.9	3.2
Spain	2,362	4,016	5,402	7,578	8,811	0.6	1.0	1.3	1.8	2.0
Portugal	184	232	446	607	764	0.0	0.1	0.1	0.1	0.2
Greece	793	935	1,262	1,431	1,639	0.2	0.2	0.3	0.3	0.4
Turkey	251	326	563	880	1,359	0.1	0.1	0.1	0.2	0.3
Yugoslavia (former)	861	885	1,055	1,399	1,220	0.2	0.2	0.3	0.3	0.3
Slovenia	0	0	0	0	339	0.0	0.0	0.0	0.0	0.1
Croatia	0	0	0	0	434	0.0	0.0	0.0	0.0	0.1
Bosnia	0	0	0	0	5	0.0	0.0	0.0	0.0	0.0
Yugoslavia (current)	0	0	0	0	442	0.0	0.0	0.0	0.0	0.1
Other S. Europe	29	30	38	50	73	0.0	0.0	0.0	0.0	0.0
Denmark	3,198	3,194	3,252	3,408	3,513	0.9	0.8	0.8	0.8	0.8
Sweden	5,846	6,698	6,935	6,700	7,190	1.6	1.7	1.7	1.6	1.6
Norway	1,920	2,072	1,851	2,128	2,180	0.5	0.5	0.5	0.5	0.5
Finland	2,173	2,485	2,499	2,785	3,246	0.6	0.6	0.6	0.7	0.7
Iceland	34	57	62	85	117	0.0	0.0	0.0	0.0	0.0
Bulgaria	983	1,079	1,114	1,029	779	0.3	0.3	0.3	0.2	0.2
Hungary	2,107	1,907	1,617	1,472	1,469	0.6	0.5	0.4	0.3	0.3
Poland	4,130	3,964	3,759	3,507	3,895	1.1	1.0	0.9	0.8	0.9
Czechoslovakia (former)	3,152	2,886	2,593	2,612	2,431	0.9	0.7	0.6	0.6	0.6
Czech Republic	0	0	0	0	1,577	0.0	0.0	0.0	0.0	0.4
Slovakia	0	0	0	0	854	0.0	0.0	0.0	0.0	0.2
Other E. Europe	649	583	480	504	554	0.2	0.1	0.1	0.1	0.1
USSR (former)	29,610	30,293	29,992	28,282	21,749	8.0	7.8	7.4	6.6	5.0
Russia	0	0	0	0	17,180	0.0	0.0	0.0	0.0	3.9
Ukraine	0	0	0	0	2,489	0.0	0.0	0.0	0.0	0.6
Baltic states	0	0	0	0	457	0.0	0.0	0.0	0.0	0.1

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Appendix table 5-49.

Scientific and technical articles, by country and field: 1981-95, selected years

Region/country	Number of scientific & technical articles published in: 1981	1985	1989	1992	1995	Percent of total scientific & technical articles published in: 1981	1985	1989	1992	1995
Other former USSR	0	0	0	0	1,623	0.0	0.0	0.0	0.0	0.4
Japan	25,088	29,618	32,832	37,402	39,498	6.8	7.6	8.1	8.8	9.0
China	1,100	1,943	3,761	4,914	6,200	0.3	0.5	0.9	1.2	1.4
Taiwan	366	687	1,470	2,738	3,884	0.1	0.2	0.4	0.6	0.9
South Korea	168	424	911	1,441	2,964	0.0	0.1	0.2	0.3	0.7
Singapore	124	289	409	577	891	0.0	0.1	0.1	0.1	0.2
Hong Kong	0	0	628	696	1,091	0.0	0.0	0.2	0.2	0.2
India	11,725	9,586	8,440	8,448	7,851	3.2	2.5	2.1	2.0	1.8
Other Asia	929	957	1,089	1,169	1,397	0.3	0.2	0.3	0.3	0.3
Australia	8,138	8,247	8,487	8,712	9,747	2.2	2.1	2.1	2.0	2.2
New Zealand	1,722	1,703	1,611	1,766	1,830	0.5	0.4	0.4	0.4	0.4
Argentina	892	1,190	1,327	1,261	1,581	0.2	0.3	0.3	0.3	0.4
Brazil	1,438	1,465	1,761	2,540	2,760	0.4	0.4	0.4	0.6	0.6
Chile	561	569	631	694	700	0.2	0.1	0.2	0.2	0.2
Other S. America	517	424	489	585	652	0.1	0.1	0.1	0.1	0.1
Mexico	648	740	878	979	1,408	0.2	0.2	0.2	0.2	0.3
Other C. America	310	259	271	319	343	0.1	0.1	0.1	0.1	0.1
Israel	3,698	4,233	3,982	3,975	4,322	1.0	1.1	1.0	0.9	1.0
Other Near East	773	1,060	1,388	1,153	1,409	0.2	0.3	0.3	0.3	0.3
Egypt	1,060	926	1,118	1,102	1,136	0.3	0.2	0.3	0.3	0.3
Other N. Africa	237	234	298	387	497	0.1	0.1	0.1	0.1	0.1
South Africa	1,782	2,025	2,130	1,936	1,744	0.5	0.5	0.5	0.5	0.4
Nigeria	780	757	651	479	342	0.2	0.2	0.2	0.1	0.1
Kenya	267	251	262	256	253	0.1	0.1	0.1	0.1	0.1
Other S. & C. Africa	685	635	680	777	772	0.2	0.2	0.2	0.2	0.2
Clinical medicine										
World	116,371	125,532	130,106	133,913	134,576	100.0	100.0	100.0	100.0	100.0
United States	48,072	50,595	50,510	50,326	50,343	41.3	40.3	38.8	37.6	37.4
Canada	4,006	4,817	5,195	5,440	5,065	3.4	3.8	4.0	4.1	3.8
United Kingdom	11,378	13,228	12,956	13,036	12,624	9.8	10.5	10.0	9.7	9.4
France	6,070	5,356	5,865	6,302	6,761	5.2	4.3	4.5	4.7	5.0
Germany	8,180	8,169	8,239	8,873	8,706	7.0	6.5	6.3	6.6	6.5
Austria	1,054	1,027	1,160	1,216	1,260	0.9	0.8	0.9	0.9	0.9
Belgium	1,275	1,274	1,304	1,373	1,444	1.1	1.0	1.0	1.0	1.1
Ireland	327	299	266	282	344	0.3	0.2	0.2	0.2	0.3
Luxembourg	12	5	3	8	7	0.0	0.0	0.0	0.0	0.0
Netherlands	1,910	2,719	3,255	3,241	3,691	1.6	2.2	2.5	2.4	2.7
Switzerland	1,926	1,835	1,880	2,031	2,067	1.7	1.5	1.4	1.5	1.5
Other W. Europe	0	0	0	1	2	0.0	0.0	0.0	0.0	0.0

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Appendix table 5-49.

Scientific and technical articles, by country and field: 1981-95, selected years

Region/country	Number of scientific & technical articles published in: 1981	1985	1989	1992	1995	Percent of total scientific & technical articles published in: 1981	1985	1989	1992	1995
Italy	2,715	3,608	4,045	4,616	4,957	2.3	2.9	3.1	3.4	3.7
Spain	512	723	1,222	1,911	2,240	0.4	0.6	0.9	1.4	1.7
Portugal	57	56	77	107	129	0.0	0.0	0.1	0.1	0.1
Greece	214	177	286	354	488	0.2	0.1	0.2	0.3	0.4
Turkey	73	84	197	372	542	0.1	0.1	0.2	0.3	0.4
Yugoslavia (former)	202	194	225	325	259	0.2	0.2	0.2	0.2	0.2
Slovenia	0	0	0	0	49	0.0	0.0	0.0	0.0	0.0
Croatia	0	0	0	0	108	0.0	0.0	0.0	0.0	0.1
Bosnia	0	0	0	0	3	0.0	0.0	0.0	0.0	0.0
Yugoslavia (current)	0	0	0	0	99	0.0	0.0	0.0	0.0	0.1
Other S. Europe	6	1	11	13	15	0.0	0.0	0.0	0.0	0.0
Denmark	1,692	1,862	1,815	1,590	1,495	1.5	1.5	1.4	1.2	1.1
Sweden	3,078	3,616	3,461	3,213	3,167	2.6	2.9	2.7	2.4	2.4
Norway	911	963	857	907	932	0.8	0.8	0.7	0.7	0.7
Finland	1,155	1,325	1,328	1,456	1,555	1.0	1.1	1.0	1.1	1.2
Iceland	13	21	27	32	48	0.0	0.0	0.0	0.0	0.0
Bulgaria	84	63	83	89	84	0.1	0.1	0.1	0.1	0.1
Hungary	574	492	302	358	274	0.5	0.4	0.2	0.3	0.2
Poland	781	579	434	376	405	0.7	0.5	0.3	0.3	0.3
Czechoslovakia (former)	608	514	541	445	359	0.5	0.4	0.4	0.3	0.3
Czech Republic	0	0	0	0	201	0.0	0.0	0.0	0.0	0.1
Slovakia	0	0	0	0	157	0.0	0.0	0.0	0.0	0.1
Other E. Europe	64	39	31	24	20	0.1	0.0	0.0	0.0	0.0
USSR (former)	3,797	3,646	3,675	2,201	1,057	3.3	2.9	2.8	1.6	0.8
Russia	0	0	0	0	914	0.0	0.0	0.0	0.0	0.7
Ukraine	0	0	0	0	59	0.0	0.0	0.0	0.0	0.0
Baltic states	0	0	0	0	46	0.0	0.0	0.0	0.0	0.0
Other former USSR	0	0	0	0	38	0.0	0.0	0.0	0.0	0.0
Japan	5,908	7,861	9,559	11,229	11,446	5.1	6.3	7.3	8.4	8.5
China	158	288	443	506	495	0.1	0.2	0.3	0.4	0.4
Taiwan	57	150	299	586	871	0.0	0.1	0.2	0.4	0.6
South Korea	19	24	89	167	337	0.0	0.0	0.1	0.1	0.3
Singapore	49	106	123	166	204	0.0	0.1	0.1	0.1	0.2
Hong Kong	0	0	347	341	394	0.0	0.0	0.3	0.3	0.3
India	1,510	1,184	1,059	1,180	955	1.3	0.9	0.8	0.9	0.7
Other Asia	255	267	317	340	393	0.2	0.2	0.2	0.3	0.3
Australia	2,563	2,728	2,954	2,992	3,294	2.2	2.2	2.3	2.2	2.4
New Zealand	508	611	591	629	630	0.4	0.5	0.5	0.5	0.5
Argentina	270	308	332	317	381	0.2	0.2	0.3	0.2	0.3
Brazil	305	297	326	640	632	0.3	0.2	0.3	0.5	0.5
Chile	251	241	276	307	289	0.2	0.2	0.2	0.2	0.2

Appendix table 5-49.

Scientific and technical articles, by country and field: 1981-95, selected years

Region/country	Number of scientific & technical articles published in: 1981	1985	1989	1992	1995	Percent of total scientific & technical articles published in: 1981	1985	1989	1992	1995
Other S. America	144	119	140	171	178	0.1	0.1	0.1	0.1	0.1
Mexico	293	247	281	232	270	0.3	0.2	0.2	0.2	0.2
Other C. America	106	102	85	90	86	0.1	0.1	0.1	0.1	0.1
Israel	1,283	1,641	1,511	1,510	1,474	1.1	1.3	1.2	1.1	1.1
Other Near East	238	328	443	450	507	0.2	0.3	0.3	0.3	0.4
Egypt	189	140	149	167	170	0.2	0.1	0.1	0.1	0.1
Other N. Africa	69	56	67	79	103	0.1	0.0	0.1	0.1	0.1
South Africa	750	810	733	595	487	0.6	0.6	0.6	0.4	0.4
Nigeria	295	287	251	202	131	0.3	0.2	0.2	0.2	0.1
Kenya	153	155	154	141	138	0.1	0.1	0.1	0.1	0.1
Other S. & C. Africa	259	305	337	367	383	0.2	0.2	0.3	0.3	0.3
Biomedical research										
World	55,303	64,717	68,616	71,502	72,002	100.0	100.0	100.0	100.0	100.0
United States	21,847	24,461	26,541	27,782	28,081	39.5	37.8	38.7	38.9	39.0
Canada	2,254	2,647	2,879	3,072	2,977	4.1	4.1	4.2	4.3	4.1
United Kingdom	4,709	5,301	5,043	5,385	5,758	8.5	8.2	7.3	7.5	8.0
France	2,883	3,251	3,423	3,789	4,013	5.2	5.0	5.0	5.3	5.6
Germany	3,915	3,963	4,358	4,346	4,559	7.1	6.1	6.4	6.1	6.3
Austria	179	212	263	328	343	0.3	0.3	0.4	0.5	0.5
Belgium	547	613	621	654	696	1.0	0.9	0.9	0.9	1.0
Ireland	66	85	97	87	170	0.1	0.1	0.1	0.1	0.2
Luxembourg	0	4	0	2	5	0.0	0.0	0.0	0.0	0.0
Netherlands	1,107	1,313	1,390	1,564	1,620	2.0	2.0	2.0	2.2	2.2
Switzerland	677	817	825	975	1,037	1.2	1.3	1.2	1.4	1.4
Other W. Europe	0	0	0	1	0	0.0	0.0	0.0	0.0	0.0
Italy	1,109	1,378	1,535	1,766	2,039	2.0	2.1	2.2	2.5	2.8
Spain	490	745	1,010	1,190	1,356	0.9	1.2	1.5	1.7	1.9
Portugal	33	40	68	97	135	0.1	0.1	0.1	0.1	0.2
Greece	65	107	109	114	132	0.1	0.2	0.2	0.2	0.2
Turkey	23	25	28	62	93	0.0	0.0	0.0	0.1	0.1
Yugoslavia (former)	152	97	136	140	108	0.3	0.1	0.2	0.2	0.1
Slovenia	0	0	0	0	43	0.0	0.0	0.0	0.0	0.1
Croatia	0	0	0	0	26	0.0	0.0	0.0	0.0	0.0
Bosnia	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Yugoslavia (current)	0	0	0	0	39	0.0	0.0	0.0	0.0	0.1
Other S. Europe	2	1	1	7	8	0.0	0.0	0.0	0.0	0.0
Denmark	468	476	533	663	602	0.8	0.7	0.8	0.9	0.8
Other former USSR	0	0	0	0	1,623	0.0	0.0	0.0	0.0	0.4
Sweden	1,030	1,172	1,299	1,204	1,223	1.9	1.8	1.9	1.7	1.7
Norway	297	319	294	317	298	0.5	0.5	0.4	0.4	0.4
Finland	310	383	365	380	450	0.6	0.6	0.5	0.5	0.6

Appendix table 5-49.
Scientific and technical articles, by country and field: 1981-95, selected years

Region/country	Number of scientific & technical articles published in: 1981	1985	1989	1992	1995	Percent of total scientific & technical articles published in: 1981	1985	1989	1992	1995
Iceland	3	9	13	13	16	0.0	0.0	0.0	0.0	0.0
Bulgaria	211	540	502	261	78	0.4	0.8	0.7	0.4	0.1
Hungary	397	335	342	239	215	0.7	0.5	0.5	0.3	0.3
Poland	572	470	367	427	297	1.0	0.7	0.5	0.6	0.4
Czechoslovakia (former)	452	367	371	440	352	0.8	0.6	0.5	0.6	0.5
Czech Republic	0	0	0	0	236	0.0	0.0	0.0	0.0	0.3
Slovakia	0	0	0	0	117	0.0	0.0	0.0	0.0	0.2
Other E. Europe	84	53	26	13	20	0.2	0.1	0.0	0.0	0.0
USSR (former)	3,148	5,618	5,177	4,473	2,716	5.7	8.7	7.5	6.3	3.8
Russia	0	0	0	0	2,401	0.0	0.0	0.0	0.0	3.3
Ukraine	0	0	0	0	131	0.0	0.0	0.0	0.0	0.2
Baltic states	0	0	0	0	48	0.0	0.0	0.0	0.0	0.1
Other former USSR	0	0	0	0	136	0.0	0.0	0.0	0.0	0.2
Japan	3,429	4,339	5,175	5,843	6,125	6.2	6.7	7.5	8.2	8.5
China	49	179	294	381	464	0.1	0.3	0.4	0.5	0.6
Taiwan	27	56	135	255	341	0.0	0.1	0.2	0.4	0.5
South Korea	12	27	65	112	238	0.0	0.0	0.1	0.2	0.3
Singapore	13	25	47	78	93	0.0	0.0	0.1	0.1	0.1
Hong Kong	0	0	68	62	85	0.0	0.0	0.1	0.1	0.1
India	1,605	1,622	1,324	1,022	1,043	2.9	2.5	1.9	1.4	1.4
Other Asia	99	121	131	132	148	0.2	0.2	0.2	0.2	0.2
Australia	1,037	1,221	1,289	1,327	1,405	1.9	1.9	1.9	1.9	2.0
New Zealand	176	208	175	230	203	0.3	0.3	0.3	0.3	0.3
Argentina	182	258	224	190	264	0.3	0.4	0.3	0.3	0.4
Brazil	266	332	436	454	497	0.5	0.5	0.6	0.6	0.7
Chile	112	68	104	92	99	0.2	0.1	0.2	0.1	0.1
Other S. America	106	78	74	86	84	0.2	0.1	0.1	0.1	0.1
Mexico	75	113	130	163	225	0.1	0.2	0.2	0.2	0.3
Other C. America	37	30	36	60	64	0.1	0.0	0.1	0.1	0.1
Israel	554	643	596	639	646	0.0	1.0	0.9	0.9	0.9
Other Near East	68	103	94	73	92	0.1	0.2	0.1	0.1	0.1
Egypt	104	44	67	65	74	0.2	0.1	0.1	0.1	0.1
Other N. Africa	19	20	17	26	37	0.0	0.0	0.0	0.0	0.1
South Africa	154	258	346	278	247	0.3	0.4	0.5	0.4	0.3
Nigeria	78	93	70	37	29	0.1	0.1	0.1	0.1	0.0
Kenya	30	31	48	33	37	0.1	0.0	0.1	0.0	0.1
Other S. & C. Africa	47	54	61	77	74	0.1	0.1	0.1	0.1	0.1
Biology										
World	39,232	34,896	34,199	34,559	34,988	100.0	100.0	100.0	100.0	100.0
United States	14,740	13,083	12,726	12,062	11,167	37.6	37.5	37.2	34.9	31.9
Canada	2,456	2,884	2,813	2,729	2,401	6.3	8.3	8.2	7.9	6.9

Appendix table 5-49.

Scientific and technical articles, by country and field: 1981-95, selected years

Region/country	Number of scientific & technical articles published in: 1981	1985	1989	1992	1995	Percent of total scientific & technical articles published in: 1981	1985	1989	1992	1995
United Kingdom	3,525	3,087	2,654	2,511	2,672	9.0	8.8	7.8	7.3	7.6
France	1,369	1,151	1,164	1,329	1,380	3.5	3.3	3.4	3.8	3.9
Germany	2,373	1,890	1,817	1,625	1,841	6.0	5.4	5.3	4.7	5.3
Austria	136	133	140	157	146	0.3	0.4	0.4	0.5	0.4
Belgium	293	355	229	184	275	0.7	1.0	0.7	0.5	0.8
Ireland	95	85	85	51	86	0.2	0.2	0.2	0.1	0.2
Luxembourg	1	1	0	1	1	0.0	0.0	0.0	0.0	0.0
Netherlands	612	608	690	730	885	1.6	1.7	2.0	2.1	2.5
Switzerland	236	214	227	252	308	0.6	0.6	0.7	0.7	0.9
Other W. Europe	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Italy	452	345	424	552	666	1.2	1.0	1.2	1.6	1.9
Spain	256	267	501	885	992	0.7	0.8	1.5	2.6	2.8
Portugal	8	11	42	64	92	0.0	0.0	0.1	0.2	0.3
Greece	59	84	107	138	154	0.2	0.2	0.3	0.4	0.4
Turkey	19	28	37	49	65	0.0	0.1	0.1	0.1	0.2
Yugoslavia (former)	26	35	43	55	60	0.1	0.1	0.1	0.2	0.2
Slovenia	0	0	0	0	11	0.0	0.0	0.0	0.0	0.0
Croatia	0	0	0	0	25	0.0	0.0	0.0	0.0	0.1
Bosnia	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Yugoslavia (current)	0	0	0	0	24	0.0	0.0	0.0	0.0	0.1
Other S. Europe	13	15	9	10	8	0.0	0.0	0.0	0.0	0.0
Denmark	258	190	205	280	357	0.7	0.5	0.6	0.8	1.0
Sweden	372	366	496	529	574	0.9	1.0	1.5	1.5	1.6
Norway	250	275	232	276	277	0.6	0.8	0.7	0.8	0.8
Finland	142	151	185	252	288	0.4	0.4	0.5	0.7	0.8
Iceland	3	6	7	19	15	0.0	0.0	0.0	0.1	0.0
Bulgaria	70	28	53	44	42	0.2	0.1	0.2	0.1	0.1
Hungary	192	118	94	62	74	0.5	0.3	0.3	0.2	0.2
Poland	226	195	187	196	170	0.6	0.6	0.5	0.6	0.5
Czechoslovakia (former)	547	421	129	176	164	1.4	1.2	0.4	0.5	0.5
Czech Republic	0	0	0	0	117	0.0	0.0	0.0	0.0	0.3
Slovakia	0	0	0	0	46	0.0	0.0	0.0	0.0	0.1
Other E. Europe	13	6	3	4	4	0.0	0.0	0.0	0.0	0.0
USSR (former)	1,113	936	796	858	927	2.8	2.7	2.3	2.5	2.6
Russia	0	0	0	0	792	0.0	0.0	0.0	0.0	2.3
Ukraine	0	0	0	0	51	0.0	0.0	0.0	0.0	0.1
Baltic states	0	0	0	0	32	0.0	0.0	0.0	0.0	0.1
Other former USSR	0	0	0	0	52	0.0	0.0	0.0	0.0	0.1
Japan	2,404	2,456	2,363	2,537	2,609	6.1	7.0	6.9	7.3	7.5
China	178	156	136	189	223	0.5	0.4	0.4	0.5	0.6
Taiwan	63	71	153	204	253	0.2	0.2	0.4	0.6	0.7

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Appendix table 5-49.

Scientific and technical articles, by country and field: 1981-95, selected years

Region/country	Number of scientific & technical articles published in:					Percent of total scientific & technical articles published in:				
	1981	1985	1989	1992	1995	1981	1985	1989	1992	1995
South Korea	9	14	25	39	87	0.0	0.0	0.1	0.1	0.2
Singapore	8	17	32	40	39	0.0	0.0	0.1	0.1	0.1
Hong Kong	0	0	23	14	59	0.0	0.0	0.1	0.0	0.2
India	1,927	857	775	730	574	4.9	2.5	2.3	2.1	1.6
Other Asia	266	235	274	306	331	0.7	0.7	0.8	0.9	0.9
Australia	1,803	1,666	1,720	1,726	1,811	4.6	4.8	5.0	5.0	5.2
New Zealand	540	465	432	466	515	1.4	1.3	1.3	1.3	1.5
Argentina	108	123	152	174	226	0.3	0.4	0.4	0.5	0.6
Brazil	205	149	149	226	264	0.5	0.4	0.4	0.7	0.8
Chile	61	70	68	67	82	0.2	0.2	0.2	0.2	0.2
Other S. America	102	84	105	119	126	0.3	0.2	0.3	0.3	0.4
Mexico	49	87	116	165	227	0.1	0.2	0.3	0.5	0.6
Other C. America	106	69	82	84	94	0.3	0.2	0.2	0.2	0.3
Israel	440	407	417	378	390	1.1	1.2	1.2	1.1	1.1
Other Near East	106	100	142	121	122	0.3	0.3	0.4	0.4	0.3
Egypt	146	111	126	113	101	0.4	0.3	0.4	0.3	0.3
Other N. Africa	23	28	34	34	38	0.1	0.1	0.1	0.1	0.1
South Africa	296	329	383	355	360	0.8	0.9	1.1	1.0	1.0
Nigeria	226	217	190	127	110	0.6	0.6	0.6	0.4	0.3
Kenya	62	51	43	67	65	0.2	0.1	0.1	0.2	0.2
Other S. & C. Africa	262	176	173	209	196	0.7	0.5	0.5	0.6	0.6
Chemistry										
World	54,432	55,268	56,126	59,500	61,221	100.0	100.0	100.0	100.0	100.0
United States	10,880	11,585	12,405	12,926	12,900	20.0	21.0	22.1	21.7	21.1
Canada	1,670	1,726	1,653	1,774	1,808	3.1	3.1	2.9	3.0	3.0
United Kingdom	3,610	3,287	3,142	3,356	3,573	6.6	5.9	5.6	5.6	5.8
France	3,199	3,261	3,231	3,462	3,665	5.9	5.9	5.8	5.8	6.0
Germany	4,587	5,139	4,864	5,014	5,499	8.4	9.3	8.7	8.4	9.0
Austria	289	302	271	301	348	0.5	0.5	0.5	0.5	0.6
Belgium	452	442	386	458	528	0.8	0.8	0.7	0.8	0.9
Ireland	84	55	60	96	74	0.2	0.1	0.1	0.2	0.1
Luxembourg	0	1	1	2	1	0.0	0.0	0.0	0.0	0.0
Netherlands	833	755	858	901	876	1.5	1.4	1.5	1.5	1.4
Switzerland	653	672	584	713	756	1.2	1.2	1.0	1.2	1.2
Other W. Europe	0	0	1	0	3	0.0	0.0	0.0	0.0	0.0
Italy	1,462	1,518	1,631	1,815	1,931	2.7	2.7	2.9	3.1	3.2
Spain	678	1,411	1,326	1,756	1,901	1.2	2.6	2.4	3.0	3.1
Portugal	26	22	77	111	140	0.0	0.0	0.1	0.2	0.2
Greece	94	159	232	219	264	0.2	0.3	0.4	0.4	0.4
Turkey	26	57	105	146	265	0.0	0.1	0.2	0.2	0.4

Appendix table 5-49.

Scientific and technical articles, by country and field: 1981-95, selected years

Region/country	Number of scientific & technical articles published in:					Percent of total scientific & technical articles published in:				
	1981	1985	1989	1992	1995	1981	1985	1989	1992	1995
Yugoslavia (former)	199	246	263	396	332	0.4	0.4	0.5	0.7	0.5
Slovenia	0	0	0	0	95	0.0	0.0	0.0	0.0	0.2
Croatia	0	0	0	0	141	0.0	0.0	0.0	0.0	0.2
Bosnia	0	0	0	0	1	0.0	0.0	0.0	0.0	0.0
Yugoslavia (current)	0	0	0	0	95	0.0	0.0	0.0	0.0	0.2
Other S. Europe	0	1	10	4	7	0.0	0.0	0.0	0.0	0.0
Denmark	223	179	184	221	283	0.4	0.3	0.3	0.4	0.5
Sweden	500	511	542	592	642	0.9	0.9	1.0	1.0	1.0
Norway	174	176	156	174	198	0.3	0.3	0.3	0.3	0.3
Finland	167	192	172	175	267	0.3	0.3	0.3	0.3	0.4
Iceland	0	2	3	2	4	0.0	0.0	0.0	0.0	0.0
Bulgaria	309	197	217	298	257	0.6	0.4	0.4	0.5	0.4
Hungary	555	504	482	460	490	1.0	0.9	0.9	0.8	0.8
Poland	1,233	1,318	1,138	1,024	1,263	2.3	2.4	2.0	1.7	2.1
Czechoslovakia (former)	961	978	925	803	782	1.8	1.8	1.6	1.3	1.3
Czech Republic	0	0	0	0	492	0.0	0.0	0.0	0.0	0.8
Slovakia	0	0	0	0	290	0.0	0.0	0.0	0.0	0.5
Other E. Europe	233	212	245	277	223	0.4	0.4	0.4	0.5	0.4
USSR (former)	9,077	8,462	8,164	7,806	6,000	16.7	15.3	14.5	13.1	9.8
Russia	0	0	0	0	4,799	0.0	0.0	0.0	0.0	7.8
Ukraine	0	0	0	0	563	0.0	0.0	0.0	0.0	0.9
Baltic states	0	0	0	0	103	0.0	0.0	0.0	0.0	0.2
Other former USSR	0	0	0	0	535	0.0	0.0	0.0	0.0	0.9
Japan	5,926	5,887	5,907	6,620	6,694	10.9	10.7	10.5	11.1	10.9
China	89	185	568	961	1,463	0.2	0.3	1.0	1.6	2.4
Taiwan	78	123	226	491	694	0.1	0.2	0.4	0.8	1.1
South Korea	49	139	317	465	829	0.1	0.3	0.6	0.8	1.4
Singapore	8	31	66	81	118	0.0	0.1	0.1	0.1	0.2
Hong Kong	0	0	58	96	152	0.0	0.0	0.1	0.2	0.2
India	3,191	2,674	2,535	2,400	2,376	5.9	4.8	4.5	4.0	3.9
Other Asia	91	114	136	163	234	0.2	0.2	0.2	0.3	0.4
Australia	926	774	763	764	890	1.7	1.4	1.4	1.3	1.5
New Zealand	154	113	126	132	152	0.3	0.2	0.2	0.2	0.2
Argentina	135	214	225	218	232	0.2	0.4	0.4	0.4	0.4
Brazil	180	155	168	250	333	0.3	0.3	0.3	0.4	0.5
Chile	60	78	80	93	75	0.1	0.1	0.1	0.2	0.1
Other S. America	65	52	51	63	84	0.1	0.1	0.1	0.1	0.1
Mexico	59	67	87	108	192	0.1	0.1	0.2	0.2	0.3
Other C. America	31	16	27	32	42	0.1	0.0	0.0	0.1	0.1
Israel	345	374	338	281	323	0.6	0.7	0.6	0.5	0.5
Other Near East	121	177	251	165	233	0.2	0.3	0.4	0.3	0.4
Egypt	383	395	475	426	440	0.7	0.7	0.8	0.7	0.7

Appendix table 5-49.

Scientific and technical articles, by country and field: 1981-95, selected years

Region/country	Number of scientific & technical articles published in:					Percent of total scientific & technical articles published in:				
	1981	1985	1989	1992	1995	1981	1985	1989	1992	1995
Other N. Africa	54	54	94	115	147	0.1	0.1	0.2	0.2	0.2
South Africa	202	192	222	216	190	0.4	0.3	0.4	0.4	0.3
Nigeria	74	52	54	46	28	0.1	0.1	0.1	0.1	0.0
Kenya	4	2	3	2	2	0.0	0.0	0.0	0.0	0.0
Other S. & C. Africa	43	37	36	39	30	0.1	0.1	0.1	0.1	0.0
				Physics						
World	45,561	54,044	61,449	66,960	74,221	100.0	100.0	100.0	100.0	100.0
United States	13,053	15,903	17,649	17,847	17,882	28.6	29.4	28.7	26.7	24.1
Canada	1,335	1,732	1,668	1,800	1,834	2.9	3.2	2.7	2.7	2.5
United Kingdom	2,904	3,026	3,048	3,446	3,955	6.4	5.6	5.0	5.1	5.3
France	2,671	3,218	3,590	3,825	4,581	5.9	6.0	5.8	5.7	6.2
Germany	3,493	4,316	4,832	5,583	6,499	7.7	8.0	7.9	8.3	8.8
Austria	239	258	271	302	435	0.5	0.5	0.4	0.5	0.6
Belgium	377	407	425	515	642	0.8	0.8	0.7	0.8	0.9
Ireland	52	58	70	87	127	0.1	0.1	0.1	0.1	0.2
Luxembourg	0	1	1	0	2	0.0	0.0	0.0	0.0	0.0
Netherlands	803	870	1,008	1,104	1,152	1.8	1.6	1.6	1.6	1.6
Switzerland	736	877	876	1,011	1,187	1.6	1.6	1.4	1.5	1.6
Other W. Europe	9	5	4	2	2	0.0	0.0	0.0	0.0	0.0
Italy	1,150	1,513	1,819	2,131	2,746	2.5	2.8	3.0	3.2	3.7
Spain	259	535	735	1,037	1,335	0.6	1.0	1.2	1.5	1.8
Portugal	32	48	85	105	127	0.1	0.1	0.1	0.2	0.2
Greece	131	159	215	258	270	0.3	0.3	0.3	0.4	0.4
Turkey	35	49	55	79	146	0.1	0.1	0.1	0.1	0.2
Yugoslavia (former)	149	193	217	285	270	0.3	0.4	0.4	0.4	0.4
Slovenia	0	0	0	0	88	0.0	0.0	0.0	0.0	0.1
Croatia	0	0	0	0	80	0.0	0.0	0.0	0.0	0.1
Bosnia	0	0	0	0	1	0.0	0.0	0.0	0.0	0.0
Yugoslavia (current)	0	0	0	0	101	0.0	0.0	0.0	0.0	0.1
Other S. Europe	0	2	1	4	17	0.0	0.0	0.0	0.0	0.0
Denmark	301	267	289	356	411	0.7	0.5	0.5	0.5	0.6
Sweden	360	501	598	629	889	0.8	0.9	1.0	0.9	1.2
Norway	100	88	95	147	153	0.2	0.2	0.2	0.2	0.2
Finland	167	200	194	238	335	0.4	0.4	0.3	0.4	0.5
Iceland	2	2	3	7	10	0.0	0.0	0.0	0.0	0.0
Bulgaria	189	157	157	232	203	0.4	0.3	0.3	0.3	0.3
Hungary	181	225	203	198	259	0.4	0.4	0.3	0.3	0.3
Poland	799	872	1,131	1,020	1,260	1.8	1.6	1.8	1.5	1.7
Czechoslovakia (former)	285	328	394	415	467	0.6	0.6	0.6	0.6	0.6
Czech Republic	0	0	0	0	318	0.0	0.0	0.0	0.0	0.4

Appendix table 5-49.

Scientific and technical articles, by country and field: 1981-95, selected years

Region/country	Number of scientific & technical articles published in: 1981	1985	1989	1992	1995	Percent of total scientific & technical articles published in: 1981	1985	1989	1992	1995
Slovakia	0	0	0	0	149	0.0	0.0	0.0	0.0	0.2
Other E. Europe	147	162	94	103	185	0.3	0.3	0.2	0.2	0.2
USSR (former)	7,647	8,422	9,347	9,341	8,300	16.8	15.6	15.2	14.0	11.2
Russia	0	0	0	0	6,106	0.0	0.0	0.0	0.0	8.2
Ukraine	0	0	0	0	1,276	0.0	0.0	0.0	0.0	1.7
Baltic states	0	0	0	0	181	0.0	0.0	0.0	0.0	0.2
Other former USSR	0	0	0	0	737	0.0	0.0	0.0	0.0	1.0
Japan	3,750	4,775	6,116	7,272	8,370	8.2	8.8	10.0	10.9	11.3
China	241	573	1,487	1,868	2,350	0.5	1.1	2.4	2.8	3.2
Taiwan	48	116	258	497	750	0.1	0.2	0.4	0.7	1.0
South Korea	34	89	193	329	859	0.1	0.2	0.3	0.5	1.2
Singapore	10	36	35	67	160	0.0	0.1	0.1	0.1	0.2
Hong Kong	0	0	37	63	189	0.0	0.0	0.1	0.1	0.3
India	1,713	1,578	1,493	1,638	1,665	3.8	2.9	2.4	2.4	2.2
Other Asia	87	89	101	107	123	0.2	0.2	0.2	0.2	0.2
Australia	619	668	613	681	980	1.4	1.2	1.0	1.0	1.3
New Zealand	68	81	68	87	89	0.1	0.1	0.1	0.1	0.1
Argentina	113	188	262	222	309	0.2	0.3	0.4	0.3	0.4
Brazil	279	342	431	612	700	0.6	0.6	0.7	0.9	0.9
Chile	14	42	34	42	57	0.0	0.1	0.1	0.1	0.1
Other S. America	52	48	66	86	106	0.1	0.1	0.1	0.1	0.1
Mexico	102	149	152	179	323	0.2	0.3	0.2	0.3	0.4
Other C. America	7	15	18	28	34	0.0	0.0	0.0	0.0	0.0
Israel	504	526	586	614	887	1.1	1.0	1.0	0.9	1.2
Other Near East	67	90	103	87	154	0.1	0.2	0.2	0.1	0.2
Egypt	85	82	119	144	177	0.2	0.2	0.2	0.2	0.2
Other N. Africa	31	30	43	56	95	0.1	0.1	0.1	0.1	0.1
South Africa	93	104	136	150	121	0.2	0.2	0.2	0.2	0.2
Nigeria	24	17	13	12	13	0.1	0.0	0.0	0.0	0.0
Kenya	2	1	4	0	4	0.0	0.0	0.0	0.0	0.0
Other S. & C. Africa	16	14	17	24	33	0.0	0.0	0.0	0.0	0.0
				Earth and space sciences						
World	16,991	17,834	18,714	20,926	23,187	100.0	100.0	100.0	100.0	100.0
United States	7,257	7,663	7,770	8,233	9,379	42.7	43.0	41.5	39.3	40.4
Canada	888	1,061	1,310	1,352	1,485	5.2	5.9	7.0	6.5	6.4
United Kingdom	1,441	1,475	1,420	1,544	1,850	8.5	8.3	7.6	7.4	8.0
France	774	681	834	929	1,217	4.6	3.8	4.5	4.4	5.2
Germany	833	914	851	1,051	1,181	4.9	5.1	4.5	5.0	5.1
Austria	49	60	51	67	101	0.3	0.3	0.3	0.3	0.4
Belgium	101	123	86	107	140	0.6	0.7	0.5	0.5	0.6

Appendix table 5-49.

Scientific and technical articles, by country and field: 1981-95, selected years

Region/country	Number of scientific & technical articles published in: 1981	1985	1989	1992	1995	Percent of total scientific & technical articles published in: 1981	1985	1989	1992	1995
Ireland	30	30	39	48	41	0.2	0.2	0.2	0.2	0.2
Luxembourg	0	0	0	0	1	0.0	0.0	0.0	0.0	0.0
Netherlands	216	356	359	400	461	1.3	2.0	1.9	1.9	2.0
Switzerland	141	131	129	179	227	0.8	0.7	0.7	0.9	1.0
Other W. Europe	0	0	0	1	0	0.0	0.0	0.0	0.0	0.0
Italy	349	319	440	568	661	2.1	1.8	2.4	2.7	2.9
Spain	55	74	228	325	403	0.3	0.4	1.2	1.6	1.7
Portugal	6	12	23	26	37	0.0	0.1	0.1	0.1	0.2
Greece	62	72	99	122	116	0.4	0.4	0.5	0.6	0.5
Turkey	17	23	45	59	90	0.1	0.1	0.2	0.3	0.4
Yugoslavia (former)	22	33	37	61	57	0.1	0.2	0.2	0.3	0.2
Slovenia	0	0	0	0	14	0.0	0.0	0.0	0.0	0.1
Croatia	0	0	0	0	27	0.0	0.0	0.0	0.0	0.1
Bosnia	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Yugoslavia (current)	0	0	0	0	16	0.0	0.0	0.0	0.0	0.1
Other S. Europe	7	7	6	8	11	0.0	0.0	0.0	0.0	0.0
Denmark	88	101	89	149	202	0.5	0.6	0.5	0.7	0.9
Sweden	120	205	236	249	288	0.7	1.1	1.3	1.2	1.2
Norway	85	134	111	177	189	0.5	0.8	0.6	0.8	0.8
Finland	58	84	96	97	153	0.3	0.5	0.5	0.5	0.7
Iceland	7	15	9	6	19	0.0	0.1	0.0	0.0	0.1
Bulgaria	35	20	29	30	27	0.2	0.1	0.2	0.1	0.1
Hungary	21	26	21	45	51	0.1	0.1	0.1	0.2	0.2
Poland	86	67	82	88	114	0.5	0.4	0.4	0.4	0.5
Czechoslovakia (former)	103	120	75	100	92	0.6	0.7	0.4	0.5	0.4
Czech Republic	0	0	0	0	70	0.0	0.0	0.0	0.0	0.3
Slovakia	0	0	0	0	23	0.0	0.0	0.0	0.0	0.1
Other E. Europe	4	4	6	6	5	0.0	0.0	0.0	0.0	0.0
USSR (former)	1,704	1,271	1,298	1,614	963	10.0	7.1	6.9	7.7	4.2
Russia	0	0	0	0	845	0.0	0.0	0.0	0.0	3.6
Ukraine	0	0	0	0	66	0.0	0.0	0.0	0.0	0.3
Baltic states	0	0	0	0	25	0.0	0.0	0.0	0.0	0.1
Other former USSR	0	0	0	0	27	0.0	0.0	0.0	0.0	0.1
Japan	395	592	737	766	969	2.3	3.3	3.9	3.7	4.2
China	240	268	143	157	196	1.4	1.5	0.8	0.8	0.8
Taiwan	12	8	18	57	122	0.1	0.0	0.1	0.3	0.5
South Korea	3	7	17	23	60	0.0	0.0	0.1	0.1	0.3
Singapore	5	11	12	15	15	0.0	0.1	0.1	0.1	0.1
Hong Kong	0	0	11	20	33	0.0	0.0	0.1	0.1	0.1
India	479	508	391	499	380	2.8	2.8	2.1	2.4	1.6
Other Asia	33	38	57	40	69	0.2	0.2	0.3	0.2	0.3
Australia	530	527	612	617	646	3.1	3.0	3.3	2.9	2.8

Appendix table 5-49.

Scientific and technical articles, by country and field: 1981-95, selected years

Region/country	Number of scientific & technical articles published in: 1981	1985	1989	1992	1995	Percent of total scientific & technical articles published in: 1981	1985	1989	1992	1995
New Zealand	160	135	128	134	145	0.9	0.8	0.7	0.6	0.6
Argentina	30	36	58	51	70	0.2	0.2	0.3	0.2	0.3
Brazil	85	70	110	163	141	0.5	0.4	0.6	0.8	0.6
Chile	47	40	34	66	63	0.3	0.2	0.2	0.3	0.3
Other S. America	17	13	14	21	27	0.1	0.1	0.1	0.1	0.1
Mexico	33	39	59	60	105	0.2	0.2	0.3	0.3	0.5
Other C. America	8	9	12	15	8	0.0	0.1	0.1	0.1	0.0
Israel	128	139	145	160	176	0.8	0.8	0.8	0.8	0.8
Other Near East	33	50	82	69	67	0.2	0.3	0.4	0.3	0.3
Egypt	19	29	48	51	42	0.1	0.2	0.3	0.2	0.2
Other N. Africa	8	9	7	15	19	0.0	0.1	0.0	0.1	0.1
South Africa	106	159	184	207	229	0.6	0.9	1.0	1.0	1.0
Nigeria	31	42	30	34	14	0.2	0.2	0.2	0.2	0.1
Kenya	7	7	6	12	4	0.0	0.0	0.0	0.1	0.0
Other S. & C. Africa	29	20	25	41	34	0.2	0.1	0.1	0.2	0.1
Engineering and technology										
World	30,710	28,004	25,442	29,684	30,585	100.0	100.0	100.0	100.0	100.0
United States	12,486	10,822	9,568	10,833	10,229	40.7	38.6	37.6	36.5	33.4
Canada	1,304	1,348	1,213	1,393	1,432	4.2	4.8	4.8	4.7	4.7
United Kingdom	2,596	2,197	1,782	1,991	2,087	8.5	7.8	7.0	6.7	6.8
France	1,020	843	961	1,213	1,354	3.3	3.0	3.8	4.1	4.4
Germany	2,322	2,167	1,786	2,119	1,823	7.6	7.7	7.0	7.1	6.0
Austria	134	108	91	102	123	0.4	0.4	0.4	0.3	0.4
Belgium	175	122	112	143	196	0.6	0.4	0.4	0.5	0.6
Ireland	20	26	25	42	40	0.1	0.1	0.1	0.1	0.1
Luxembourg	0	0	1	2	3	0.0	0.0	0.0	0.0	0.0
Netherlands	370	311	308	406	426	1.2	1.1	1.2	1.4	1.4
Switzerland	360	283	190	206	235	1.2	1.0	0.7	0.7	0.8
Other W. Europe	1	0	0	0	2	0.0	0.0	0.0	0.0	0.0
Italy	428	472	533	669	831	1.4	1.7	2.1	2.3	2.7
Spain	72	139	205	312	376	0.2	0.5	0.8	1.1	1.2
Portugal	12	26	54	81	81	0.0	0.1	0.2	0.3	0.3
Greece	118	122	162	183	174	0.4	0.4	0.6	0.6	0.6
Turkey	47	49	86	102	145	0.2	0.2	0.3	0.3	0.5
Yugoslavia (former)	85	60	97	103	109	0.3	0.2	0.4	0.3	0.4
Slovenia	0	0	0	0	27	0.0	0.0	0.0	0.0	0.1
Croatia	0	0	0	0	19	0.0	0.0	0.0	0.0	0.1
Bosnia	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Yugoslavia (current)	0	0	0	0	63	0.0	0.0	0.0	0.0	0.2
Other S. Europe	1	3	0	3	6	0.0	0.0	0.0	0.0	0.0

Appendix table 5-49.

Scientific and technical articles, by country and field: 1981-95, selected years

Region/country	Number of scientific & technical articles published in:					Percent of total scientific & technical articles published in:				
	1981	1985	1989	1992	1995	1981	1985	1989	1992	1995
Denmark	94	65	81	99	106	0.3	0.2	0.3	0.3	0.3
Sweden	305	255	240	230	322	1.0	0.9	0.9	0.8	1.1
Norway	70	73	67	101	99	0.2	0.3	0.3	0.3	0.3
Finland	117	106	115	149	168	0.4	0.4	0.5	0.5	0.5
Iceland	2	0	0	3	2	0.0	0.0	0.0	0.0	0.0
Bulgaria	52	43	39	50	63	0.2	0.2	0.2	0.2	0.2
Hungary	88	61	79	46	64	0.3	0.2	0.3	0.2	0.2
Poland	338	295	269	270	292	1.1	1.1	1.1	0.9	1.0
Czechoslovakia (former)	153	117	109	163	164	0.5	0.4	0.4	0.5	0.5
Czech Republic	0	0	0	0	115	0.0	0.0	0.0	0.0	0.4
Slovakia	0	0	0	0	49	0.0	0.0	0.0	0.0	0.2
Other E. Europe	53	57	34	44	65	0.2	0.2	0.1	0.1	0.2
USSR (former)	2,340	1,663	1,239	1,577	1,550	7.6	5.9	4.9	5.3	5.1
Russia	0	0	0	0	1,150	0.0	0.0	0.0	0.0	3.8
Ukraine	0	0	0	0	314	0.0	0.0	0.0	0.0	1.0
Baltic states	0	0	0	0	20	0.0	0.0	0.0	0.0	0.1
Other former USSR	0	0	0	0	66	0.0	0.0	0.0	0.0	0.2
Japan	2,827	3,213	2,580	2,843	3,018	9.2	11.5	10.1	9.6	9.9
China	113	227	567	657	757	0.4	0.8	2.2	2.2	2.5
Taiwan	52	125	342	603	796	0.2	0.4	1.3	2.0	2.6
South Korea	36	109	167	279	515	0.1	0.4	0.7	0.9	1.7
Singapore	23	44	80	109	222	0.1	0.2	0.3	0.4	0.7
Hong Kong	0	0	62	78	150	0.0	0.0	0.2	0.3	0.5
India	954	863	737	887	779	3.1	3.1	2.9	3.0	2.5
Other Asia	73	59	45	55	72	0.2	0.2	0.2	0.2	0.2
Australia	460	470	363	467	582	1.5	1.7	1.4	1.6	1.9
New Zealand	89	62	66	61	68	0.3	0.2	0.3	0.2	0.2
Argentina	43	48	58	61	83	0.1	0.2	0.2	0.2	0.3
Brazil	72	68	77	125	125	0.2	0.2	0.3	0.4	0.4
Chile	10	15	18	13	17	0.0	0.1	0.1	0.0	0.1
Other S. America	21	18	25	22	24	0.1	0.1	0.1	0.1	0.1
Mexico	27	24	35	50	48	0.1	0.1	0.1	0.2	0.2
Other C. America	9	12	9	6	9	0.0	0.0	0.0	0.0	0.0
Israel	293	349	250	270	284	1.0	1.2	1.0	0.9	0.9
Other Near East	104	171	233	165	210	0.3	0.6	0.9	0.6	0.7
Egypt	119	110	126	121	121	0.4	0.4	0.5	0.4	0.4
Other N. Africa	15	18	19	47	37	0.0	0.1	0.1	0.2	0.1
South Africa	143	131	92	109	82	0.5	0.5	0.4	0.4	0.3
Nigeria	42	30	36	15	12	0.1	0.1	0.1	0.1	0.0
Kenya	5	1	0	1	2	0.0	0.0	0.0	0.0	0.0
Other S. & C. Africa	22	14	15	16	14	0.1	0.0	0.1	0.1	0.0

Appendix table 5-49.

Scientific and technical articles, by country and field: 1981-95, selected years

Region/country	Number of scientific & technical articles published in: 1981	1985	1989	1992	1995	Percent of total scientific & technical articles published in: 1981	1985	1989	1992	1995
					Mathematics					
World	10,334	9,551	9,193	8,302	7,987	100.0	100.0	100.0	100.0	100.0
United States	3,943	3,659	3,664	3,165	2,811	38.2	38.3	39.9	38.1	35.2
Canada	527	441	501	398	357	5.1	4.6	5.4	4.8	4.5
United Kingdom	631	655	526	537	461	6.1	6.9	5.7	6.5	5.8
France	581	661	686	699	840	5.6	6.9	7.5	8.4	10.5
Germany	1,134	752	606	558	546	11.0	7.9	6.6	6.7	6.8
Austria	80	79	68	49	51	0.8	0.8	0.7	0.6	0.6
Belgium	89	88	70	54	75	0.9	0.9	0.8	0.7	0.9
Ireland	26	15	23	15	18	0.3	0.2	0.3	0.2	0.2
Luxembourg	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Netherlands	142	147	149	146	128	1.4	1.5	1.6	1.8	1.6
Switzerland	72	66	72	56	79	0.7	0.7	0.8	0.7	1.0
Other W. Europe	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Italy	138	224	293	234	286	1.3	2.3	3.2	2.8	3.6
Spain	40	122	175	162	208	0.4	1.3	1.9	2.0	2.6
Portugal	10	17	20	16	23	0.1	0.2	0.2	0.2	0.3
Greece	50	55	52	43	41	0.5	0.6	0.6	0.5	0.5
Turkey	11	11	10	11	13	0.1	0.1	0.1	0.1	0.2
Yugoslavia (former)	26	27	37	34	25	0.3	0.3	0.4	0.4	0.3
Slovenia	0	0	0	0	12	0.0	0.0	0.0	0.0	0.2
Croatia	0	0	0	0	8	0.0	0.0	0.0	0.0	0.1
Bosnia	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
Yugoslavia (current)	0	0	0	0	5	0.0	0.0	0.0	0.0	0.1
Other S. Europe	0	0	0	1	1	0.0	0.0	0.0	0.0	0.0
Denmark	74	54	56	50	57	0.7	0.6	0.6	0.6	0.7
Sweden	81	72	63	54	85	0.8	0.8	0.7	0.7	1.1
Norway	33	44	39	29	34	0.3	0.5	0.4	0.3	0.4
Finland	57	44	44	38	30	0.6	0.5	0.5	0.5	0.4
Iceland	4	2	0	3	3	0.0	0.0	0.0	0.0	0.0
Bulgaria	33	31	34	25	25	0.3	0.3	0.4	0.3	0.3
Hungary	99	146	94	64	42	1.0	1.5	1.0	0.8	0.5
Poland	95	168	151	106	94	0.9	1.8	1.6	1.3	1.2
Czechoslovakia (former)	43	41	49	70	51	0.4	0.4	0.5	0.8	0.6
Czech Republic	0	0	0	0	28	0.0	0.0	0.0	0.0	0.4
Slovakia	0	0	0	0	23	0.0	0.0	0.0	0.0	0.3
Other E. Europe	51	50	41	33	32	0.5	0.5	0.4	0.4	0.4
USSR (former)	784	275	296	412	236	7.6	2.9	3.2	5.0	3.0
Russia	0	0	0	0	173	0.0	0.0	0.0	0.0	2.2

Appendix table 5-49.
Scientific and technical articles, by country and field: 1981-95, selected years

Region/country	Number of scientific & technical articles published in: 1981	1985	1989	1992	1995	Percent of total scientific & technical articles published in: 1981	1985	1989	1992	1995
Ukraine	0	0	0	0	29	0.0	0.0	0.0	0.0	0.4
Baltic states	0	0	0	0	2	0.0	0.0	0.0	0.0	0.0
Other former USSR	0	0	0	0	32	0.0	0.0	0.0	0.0	0.4
Japan	449	495	395	292	267	4.3	5.2	4.3	3.5	3.3
China	32	67	123	195	252	0.3	0.7	1.3	2.3	3.2
Taiwan	29	38	39	45	57	0.3	0.4	0.4	0.5	0.7
South Korea	6	15	38	27	39	0.1	0.2	0.4	0.3	0.5
Singapore	8	19	14	21	40	0.1	0.2	0.2	0.3	0.5
Hong Kong	0	0	22	22	29	0.0	0.0	0.2	0.3	0.4
India	346	300	126	92	79	3.3	3.1	1.4	1.1	1.0
Other Asia	25	34	28	26	27	0.2	0.4	0.3	0.3	0.3
Australia	200	193	173	138	139	1.9	2.0	1.9	1.7	1.7
New Zealand	27	28	25	27	28	0.3	0.3	0.3	0.3	0.4
Argentina	11	15	16	28	16	0.1	0.2	0.2	0.3	0.2
Brazil	46	52	64	70	68	0.4	0.5	0.7	0.8	0.9
Chile	6	15	17	14	18	0.1	0.2	0.2	0.2	0.2
Other S. America	10	12	14	17	23	0.1	0.1	0.2	0.2	0.3
Mexico	10	14	18	22	18	0.1	0.1	0.2	0.3	0.2
Other C. America	6	6	2	4	6	0.1	0.1	0.0	0.0	0.1
Israel	151	154	139	123	142	1.5	1.6	1.5	1.5	1.8
Other Near East	36	41	40	23	24	0.3	0.4	0.4	0.3	0.3
Egypt	15	15	8	15	11	0.1	0.2	0.1	0.2	0.1
Other N. Africa	18	19	17	15	21	0.2	0.2	0.2	0.2	0.3
South Africa	38	42	34	26	28	0.4	0.4	0.4	0.3	0.4
Nigeria	10	19	7	6	5	0.1	0.2	0.1	0.1	0.1
Kenya	4	3	4	0	1	0.0	0.0	0.0	0.0	0.0
Other S. & C. Africa	7	15	16	4	8	0.1	0.2	0.2	0.0	0.1

NOTE: Data for Hong Kong are included with the United Kingdom through 1986. Details may not add to totals because of rounding.

SOURCES: Institute for Scientific Information, Science Citation Index, CHI Research Inc., Science Indicators database; and National Science Foundation, unpublished tabulations.

See figures 5-24 and 5-25.

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Appendix table 5-50.

Scientific and technical article output of selected countries compared to gross domestic product: 1995

Country	Number of articles	GDP (billions of U.S. $)	Articles/ GDP (billions of U.S. $)
Israel	4,322	80	54
Sweden	7,190	177	41
Switzerland	5,896	159	37
Finland	3,246	92	35
Denmark	3,513	113	31
Netherlands	9,239	302	31
New Zealand	1,830	62	29
United Kingdom	32,980	1,138	29
Canada	17,359	694	25
Australia	9,747	405	24
Iceland	117	5	23
Slovakia	854	39	22
Croatia	434	20	22
Russia	17,180	796	22
[illegible]ia (current)	442	21	21
Germany	30,654	1,452	21
Norway	2,180	106	21
France	23,811	1,173	20
Belgium	3,996	197	20
Hungary	1,469	73	20
United States	142,792	7,248	20
Austria	2,807	152	18
Bulgaria	779	43	18
Poland	3,895	227	17
Ireland	900	55	16
Greece	1,639	102	16
Spain	8,811	565	16
Slovenia	339	23	15
Czech Republic	1,577	106	15
Japan	39,498	2,679	15
Ukraine	2,489	175	14
Singapore	891	66	13
Taiwan	3,884	291	13
Italy	14,117	1,089	13
South Africa	1,744	215	8
Hong Kong	1,091	152	7
Kenya	253	37	7
Egypt	1,136	171	7
Portugal	764	116	7
Chile	700	113	6
Argentina	1,581	279	6
India	7,851	1,409	6
South Korea	2,964	591	5
Bosnia	5	1	5
Turkey	1,359	346	4
Brazil	2,760	977	3
Nigeria	342	136	3
Luxembourg	20	10	2
Mexico	1,408	721	2
China	6,200	3,500	2

SOURCES: **World GDP data**—U.S. Central Intelligence Agency, World Fact Book <<http://www.odci.gov/cia/publications/nsolo/wbf-eco.htm>> (September 1997); **publications data**—Institute for Scientific Information, Science Citation Index; CHI Research Inc., Science Indicators database, and National Science Foundation, unpublished tabulations.

See figure 5-26.

Science & Engineering Indicators – 1998

Appendix table 5-51.

Distribution of scientific and technical articles for selected countries, by field: 1981-95, selected years

(Percentages)

Field	Articles published in:					Articles published in:				
	1981	1985	1989	1992	1995	1981	1985	1989	1992	1995
	World					**United States**				
Clinical medicine	31.5	32.2	32.2	31.5	30.7	36.3	36.7	35.9	35.2	35.3
Biomedical research	15.0	16.6	17.0	16.8	16.4	16.5	17.8	18.8	19.4	19.7
Biology	10.6	9.0	8.5	8.1	8.0	11.1	9.5	9.0	8.4	7.8
Chemistry	14.8	14.2	13.9	14.0	14.0	8.2	8.4	8.8	9.0	9.0
Physics	12.3	13.9	15.2	15.7	16.9	9.9	11.5	12.5	12.5	12.5
Earth & space sciences	4.6	4.6	4.6	4.9	5.3	5.5	5.6	5.5	5.8	6.6
Engineering & technology	8.3	7.2	6.3	7.0	7.0	9.4	7.9	6.8	7.6	7.2
Mathematics	2.8	2.4	2.3	2.0	1.8	3.0	2.7	2.6	2.2	2.0
	Canada					**United Kingdom**				
Clinical medicine	27.7	28.9	30.1	30.3	29.2	36.9	41.0	42.4	41.0	38.3
Biomedical research	15.6	15.9	16.7	17.1	17.1	15.3	16.4	16.5	16.9	17.5
Biology	17.0	17.3	16.3	15.2	13.8	11.4	9.6	8.7	7.9	8.1
Chemistry	11.6	10.4	9.6	9.9	10.4	11.7	10.2	10.3	10.6	10.8
Physics	9.2	10.4	9.7	10.0	10.6	9.4	9.4	10.0	10.8	12.0
Earth & space sciences	6.1	6.4	7.6	7.5	8.6	4.7	4.6	4.6	4.9	5.6
Engineering & technology	9.0	8.1	7.0	7.8	8.2	8.4	6.8	5.8	6.3	6.3
Mathematics	3.6	2.6	2.9	2.2	2.1	2.0	2.0	1.7	1.7	1.4
	France					**Germany**				
Clinical medicine	32.7	29.1	29.7	29.2	28.4	30.5	29.9	30.1	30.4	28.4
Biomedical research	15.5	17.6	17.3	17.6	16.9	14.6	14.5	15.9	14.9	14.9
Biology	7.4	6.2	5.9	6.2	5.8	8.8	6.9	6.6	5.6	6.0
Chemistry	17.2	17.7	16.4	16.1	15.4	17.1	18.8	17.8	17.2	17.9
Physics	14.4	17.5	18.2	17.8	19.2	13.0	15.8	17.7	19.1	21.2
Earth & space sciences	4.2	3.7	4.2	4.3	5.1	3.1	3.3	3.1	3.6	3.9
Engineering & technology	5.5	4.6	4.9	5.6	5.7	8.7	7.9	6.5	7.3	5.9
Mathematics	3.1	3.6	3.5	3.2	3.5	4.2	2.8	2.2	1.9	1.8
	Netherlands					**Switzerland**				
Clinical medicine	31.9	38.4	40.6	38.2	40.0	40.1	37.5	39.3	37.5	35.1
Biomedical research	18.5	18.5	17.3	18.4	17.5	14.1	16.7	17.2	18.0	17.6
Biology	10.2	8.6	8.6	8.6	9.6	4.9	4.4	4.7	4.6	5.2
Chemistry	13.9	10.7	10.7	10.6	9.5	13.6	13.7	12.2	13.1	12.8
Physics	13.4	12.3	12.6	13.0	12.5	15.3	17.9	18.3	18.6	20.1
Earth & space sciences	3.6	5.0	4.5	4.7	5.0	2.9	2.7	2.7	3.3	3.9
Engineering & technology	6.2	4.4	3.8	4.8	4.6	7.5	5.8	4.0	3.8	4.0
Mathematics	2.4	2.1	1.9	1.7	1.4	1.5	1.3	1.5	1.0	1.3
	Other Western Europe					**Sweden**				
Clinical medicine	43.1	41.5	43.9	42.7	39.5	52.7	54.0	49.9	48.0	44.0
Biomedical research	12.8	14.6	15.8	15.9	15.7	17.6	17.5	18.7	18.0	17.0
Biology	8.5	9.2	7.3	5.8	6.6	6.4	5.5	7.2	7.9	8.0
Chemistry	13.3	12.8	11.6	12.7	12.3	8.6	7.6	7.8	8.8	8.9
Physics	10.9	11.6	12.4	13.4	15.6	6.2	7.5	8.6	9.4	12.4
Earth & space sciences	2.9	3.4	2.8	3.3	3.7	2.1	3.1	3.4	3.7	4.0
Engineering & technology	5.3	4.1	3.7	4.3	4.7	5.2	3.8	3.5	3.4	4.5
Mathematics	3.1	2.9	2.6	1.8	1.9	1.4	1.1	0.9	0.8	1.2

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Appendix table 5-51.

Distribution of scientific and technical articles for selected countries, by field: 1981-95, selected years
(Percentages)

Field	Articles published in:					Articles published in:				
	1981	1985	1989	1992	1995	1981	1985	1989	1992	1995
	Other Northern Europe					**Italy**				
Clinical medicine	51.5	53.4	52.5	47.4	44.5	34.8	38.5	37.7	37.4	35.1
Biomedical research	14.7	15.2	15.7	16.3	15.1	14.2	14.7	14.3	14.3	14.4
Biology	8.9	8.0	8.2	9.8	10.3	5.8	3.7	4.0	4.5	4.7
Chemistry	7.7	7.0	6.7	6.8	8.3	18.7	16.2	15.2	14.7	13.7
Physics	7.8	7.1	7.6	8.9	10.0	14.7	16.1	17.0	17.3	19.5
Earth & space sciences	3.2	4.3	4.0	5.1	6.2	4.5	3.4	4.1	4.6	4.7
Engineering & technology	3.9	3.1	3.4	4.2	4.1	5.5	5.0	5.0	5.4	5.9
Mathematics	2.3	1.8	1.8	1.4	1.4	1.8	2.4	2.7	1.9	2.0
	Spain					**Other Southern Europe**				
Clinical medicine	21.7	18.0	22.6	25.2	25.4	26.1	21.3	23.7	26.8	28.3
Biomedical research	20.7	18.6	18.7	15.7	15.4	13.0	11.2	10.2	9.6	9.4
Biology	10.8	6.6	9.3	11.7	11.3	5.9	7.2	7.1	7.2	7.5
Chemistry	28.7	35.1	24.5	23.2	21.6	16.3	20.1	20.4	20.1	19.9
Physics	11.0	13.3	13.6	13.7	15.2	16.4	18.7	17.0	16.7	16.4
Earth & space sciences	2.3	1.8	4.2	4.3	4.6	5.4	6.1	6.2	6.3	6.2
Engineering & technology	3.0	3.5	3.8	4.1	4.3	12.4	10.8	11.9	10.8	10.2
Mathematics	1.7	3.0	3.2	2.1	2.4	4.6	4.6	3.5	2.4	2.0
	Eastern Europe					**Russia**[a]				
Clinical medicine	19.2	16.2	14.5	14.2	12.5	12.0	12.3	7.8	5.3	28.3
Biomedical research	15.6	16.9	16.8	15.1	10.5	18.5	17.3	15.8	14.0	9.4
Biology	9.5	7.4	4.9	5.3	5.0	3.1	2.7	3.0	4.6	7.5
Chemistry	29.9	30.8	31.4	31.4	33.0	27.9	27.2	27.6	27.9	19.9
Physics	14.5	16.7	20.7	21.6	26.0	27.8	31.2	33.0	35.5	16.4
Earth & space sciences	2.3	2.3	2.2	2.9	3.2	4.2	4.3	5.7	4.9	6.2
Engineering & technology	6.2	5.5	5.5	6.3	7.1	5.5	4.1	5.6	6.7	10.2
Mathematics	2.9	4.2	3.9	3.3	2.7	0.9	1.0	1.5	1.0	2.0
	Japan					**China**				
Clinical medicine	23.5	26.5	29.1	30.0	29.0	14.4	14.8	11.8	10.3	8.0
Biomedical research	13.7	14.6	15.8	15.6	15.5	4.5	9.2	7.8	7.8	7.5
Biology	9.6	8.3	7.2	6.8	6.6	16.2	8.0	3.6	3.8	3.6
Chemistry	23.6	19.9	18.0	17.7	16.9	8.1	9.5	15.1	19.6	23.6
Physics	14.9	16.1	18.6	19.4	21.2	21.9	29.5	39.5	38.0	37.9
Earth & space sciences	1.6	2.0	2.2	2.0	2.5	21.8	13.8	3.8	3.2	3.2
Engineering & technology	11.3	10.8	7.9	7.6	7.6	10.3	11.7	15.1	13.4	12.2
Mathematics	1.8	1.7	1.2	0.8	0.7	2.9	3.4	3.3	4.0	4.1
	Asian newly industrializing economies[b]					**India**				
Clinical medicine	19.7	20.0	25.1	23.1	20.5	12.9	12.4	12.5	14.0	12.2
Biomedical research	7.6	7.9	9.4	9.4	8.6	13.7	16.9	15.7	12.1	13.3
Biology	12.1	7.1	6.7	5.5	5.0	16.4	8.9	9.2	8.6	7.3
Chemistry	21.2	20.7	19.6	20.7	20.3	27.2	27.9	30.0	28.4	30.3
Physics	13.6	17.1	15.2	17.6	22.2	14.6	16.5	17.7	19.4	21.2
Earth & space sciences	3.0	2.1	1.8	2.2	2.6	4.1	5.3	4.6	5.9	4.8
Engineering & technology	16.7	20.0	19.0	19.6	19.0	8.1	9.0	8.7	10.5	9.9
Mathematics	6.1	5.0	3.2	2.2	1.9	3.0	3.1	1.5	1.1	1.0

Appendix table 5-51.

Distribution of scientific and technical articles for selected countries, by field: 1981-95, selected years

(Percentages)

	Articles published in:					Articles published in:				
Field	1981	1985	1989	1992	1995	1981	1985	1989	1992	1995
	Other Asian nations					**Australia & New Zealand**				
Clinical medicine	27.4	27.9	29.1	29.1	28.1	31.1	33.6	35.1	34.6	33.9
Biomedical research	10.7	12.6	12.0	11.3	10.6	12.3	14.4	14.5	14.9	13.9
Biology	28.6	24.6	25.2	26.2	23.7	23.8	21.4	21.3	20.9	20.1
Chemistry	9.8	11.9	12.5	13.9	16.8	11.0	8.9	8.8	8.6	9.0
Physics	9.4	9.3	9.3	9.2	8.8	7.0	7.5	6.7	7.3	9.2
Earth & space sciences	3.6	4.0	5.2	3.4	4.9	7.0	6.7	7.3	7.2	6.8
Engineering & technology	7.9	6.2	4.1	4.7	5.2	5.6	5.3	4.2	5.0	5.6
Mathematics	2.7	3.6	2.6	2.2	1.9	2.3	2.2	2.0	1.6	1.4
	Mexico					**Argentina**				
Clinical medicine	45.2	33.4	32.0	23.7	19.2	30.3	25.9	25.0	25.1	24.1
Biomedical research	11.6	15.3	14.8	16.6	16.0	20.4	21.7	16.9	15.1	16.7
Biology	7.6	11.8	13.2	16.9	16.1	12.1	10.3	11.5	13.8	14.3
Chemistry	9.1	9.1	9.9	11.0	13.6	15.1	18.0	17.0	17.3	14.7
Physics	15.7	20.1	17.3	18.3	22.9	12.7	15.8	19.7	17.6	19.5
Earth & space sciences	5.1	5.3	6.7	6.1	7.5	3.4	3.0	4.4	4.0	4.4
Engineering & technology	4.2	3.2	4.0	5.1	3.4	4.8	4.0	4.4	4.8	5.2
Mathematics	1.5	1.9	2.1	2.2	1.3	1.2	1.3	1.2	2.2	1.0
	Brazil					**Chile**				
Clinical medicine	21.2	20.3	18.5	25.2	22.9	44.7	42.4	43.7	44.2	41.3
Biomedical research	18.5	22.7	24.8	17.9	18.0	20.0	12.0	16.5	13.3	14.1
Biology	14.3	10.2	8.5	8.9	9.6	10.9	12.3	10.8	9.7	11.7
Chemistry	12.5	10.6	9.5	9.8	12.1	10.7	13.7	12.7	13.4	10.7
Physics	19.4	23.3	24.5	24.1	25.4	2.5	7.4	5.4	6.1	8.1
Earth & space sciences	5.9	4.8	6.2	6.4	5.1	8.4	7.0	5.4	9.5	9.0
Engineering & technology	5.0	4.6	4.4	4.9	4.5	1.8	2.6	2.9	1.9	2.4
Mathematics	3.2	3.5	3.6	2.8	2.5	1.1	2.6	2.7	2.0	2.6
	Other Central & South America					**Israel**				
Clinical medicine	30.2	32.4	29.6	28.9	26.5	34.7	38.8	37.9	38.0	34.1
Biomedical research	17.3	15.8	14.5	16.2	14.9	15.0	15.2	15.0	16.1	14.9
Biology	25.2	22.4	24.6	22.5	22.1	11.9	9.6	10.5	9.5	9.0
Chemistry	11.6	10.0	10.3	10.5	12.7	9.3	8.8	8.5	7.1	7.5
Physics	7.1	9.2	11.1	12.6	14.1	13.6	12.4	14.7	15.4	20.5
Earth & space sciences	3.0	3.2	3.4	4.0	3.5	3.5	3.3	3.6	4.0	4.1
Engineering & technology	3.6	4.4	4.5	3.1	3.3	7.9	8.2	6.3	6.8	6.6
Mathematics	1.9	2.6	2.1	2.3	2.9	4.1	3.6	3.5	3.1	3.3
	Other Near East					**Egypt**				
Clinical medicine	30.8	30.9	31.9	39.0	36.0	17.8	15.1	13.3	15.2	15.0
Biomedical research	8.8	9.7	6.8	6.3	6.5	9.8	4.8	6.0	5.9	6.5
Biology	13.7	9.4	10.2	10.5	8.7	13.8	12.0	11.3	10.3	8.9
Chemistry	15.7	16.7	18.1	14.3	16.5	36.1	42.7	42.5	38.7	38.7
Physics	8.7	8.5	7.4	7.5	10.9	8.0	8.9	10.6	13.1	15.6
Earth & space sciences	4.3	4.7	5.9	6.0	4.8	1.8	3.1	4.3	4.6	3.7
Engineering & technology	13.5	16.1	16.8	14.3	14.9	11.2	11.9	11.3	11.0	10.7
Mathematics	4.7	3.9	2.9	2.0	1.7	1.4	1.6	0.7	1.4	1.0

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Appendix table 5-51.
Distribution of scientific and technical articles for selected countries, by field: 1981-95, selected years
(Percentages)

Field	Articles published in:					Articles published in:				
	1981	1985	1989	1992	1995	1981	1985	1989	1992	1995
	Other North Africa					**South Africa**				
Clinical medicine	29.1	23.9	22.5	20.4	20.7	42.1	40.0	34.4	30.7	27.9
Biomedical research	8.0	8.5	5.7	6.7	7.4	8.6	12.7	16.2	14.4	14.2
Biology	9.7	12.0	11.4	8.8	7.6	16.6	16.2	18.0	18.3	20.6
Chemistry	22.8	23.1	31.5	29.7	29.6	11.3	9.5	10.4	11.2	10.9
Physics	13.1	12.8	14.4	14.5	19.1	5.2	5.1	6.4	7.7	6.9
Earth & space sciences	3.4	3.8	2.3	3.9	3.8	5.9	7.9	8.6	10.7	13.1
Engineering & technology	6.3	7.7	6.4	12.1	7.4	8.0	6.5	4.3	5.6	4.7
Mathematics	7.6	8.1	5.7	3.9	4.2	2.1	2.1	1.6	1.3	1.6
	Other Central & South Africa									
Clinical medicine	40.8	45.5	46.6	47.0	47.7					
Biomedical research	8.9	10.8	11.2	9.7	10.2					
Biology	31.8	27.0	25.5	26.7	27.1					
Chemistry	7.0	5.5	5.8	5.8	4.4					
Physics	2.4	1.9	2.1	2.4	3.7					
Earth & space sciences	3.9	4.2	3.8	5.8	3.8					
Engineering & technology	4.0	2.7	3.2	2.1	2.0					
Mathematics	1.2	2.3	1.7	0.7	1.0					

NOTE: Details may not add to totals because of rounding.

[a] Data are for the former USSR except for 1995.

[b] Data for Hong Kong are included with United Kingdom through 1986.

SOURCES: Institute for Scientific Information, Science Citation Index; CHI Research Inc., Science Indicators database; and National Science Foundation, unpublished tabulations.

See figure 5-27 and text table 5-12.

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Appendix table 5-52.
Coauthored and internationally coauthored scientific and technical articles for selected countries: 1981 and 1995

Country	All articles[a]		Multi-author articles (percent of total)		Internationally coauthored (percent of coauthored)	
	1981	1995	1981	1995	1981	1995
World[b]	368,934	438,767	33	50	17	29
United States	132,278	142,792	43	58	18	32
Canada	14,440	17,359	40	59	43	52
United Kingdom	30,794	32,980	32	55	42	53
France	18,567	23,811	44	64	35	53
Germany	26,837	30,654	31	54	45	61
Austria	2,160	2,807	39	65	45	64
Belgium	3,309	3,996	42	67	52	68
Ireland	700	900	39	61	50	66
Netherlands	5,993	9,239	35	65	48	54
Switzerland	4,801	5,896	40	63	67	76
Italy	7,803	14,117	51	71	32	49
Portugal	184	764	50	70	64	72
Spain	2,362	8,811	34	57	35	55
Greece	793	1,639	35	62	58	62
Turkey	251	1,359	44	56	69	46
Denmark	3,198	3,513	50	69	42	63
Sweden	5,846	7,190	50	66	36	59
Norway	1,920	2,180	44	68	40	58
Finland	2,173	3,246	48	70	33	50
Bulgaria	983	779	27	56	57	74
Hungary	2,107	1,469	38	70	44	73
Poland	4,130	3,895	28	59	55	78
Former USSR states	29,610	21,749	15	37	18	70
Japan	25,088	39,498	30	53	17	27
China	1,100	6,200	27	54	47	53
Taiwan	366	3,884	39	54	67	34
South Korea	168	2,964	50	62	78	46
Singapore	124	891	39	45	48	59
Hong Kong[c]	NA	1,091	NA	57	NA	69
India	11,725	7,851	18	35	30	43
Australia	8,138	9,747	32	54	38	49
New Zealand	1,722	1,830	30	54	44	58
Argentina	892	1,581	35	58	34	53
Brazil	1,438	2,760	46	67	53	64
Chile	561	700	41	67	50	67
Mexico	648	1,408	52	66	53	67
Israel	3,698	4,322	51	66	44	56
Egypt	1,060	1,136	36	51	42	57
South Africa	1,782	1,744	44	55	29	48
Nigeria	780	342	28	55	50	64
Kenya	267	253	32	70	68	84

NA = not available

NOTE: Details may not add to totals because of rounding.

[a] Data include all scientific and technical articles in natural science and engineering fields.

[b] International collaboration rates for the entire world cannot be compared to country rates because, regardless of the number of countries involved, an internationally coauthored article is counted only once.

[c] Data for Hong Kong are included with United Kingdom through 1986.

SOURCES: Institute for Scientific Information, Science Citation Index; CHI Research Inc., Science Indicators database; and National Science Foundation, unpublished tabulations.

Appendix table 5-53.

Coauthored and internationally coauthored scientific and technical articles for selected countries, by field: 1981-85 and 1991-95

	Number of articles (in thousands)						Percent of total articles			
	Total		Multi-author		Internationally coauthored		Multi-author		Internationally coauthored	
Country	1981-85	1991-95	1981-85	1991-95	1981-85	1991-95	1981-85	1991-95	1981-85	1991-95
	All natural science and engineering fields									
World[a]	1,875.4	2,117.3	657.3	1,002.9	121.0	271.9	35	47	6	13
United States	697.9	773.7	311.8	431.3	60.0	126.2	45	56	9	16
United Kingdom	168.5	186.2	58.9	96.2	24.7	48.1	35	52	15	26
Germany	145.0	174.6	49.3	88.1	23.5	52.7	34	50	16	30
France	100.4	132.2	46.7	81.3	17.9	42.2	46	61	18	32
Italy	48.0	76.9	26.9	53.5	9.0	25.2	56	70	19	33
Other S. Europe	29.9	74.0	12.1	41.7	5.7	23.9	41	56	19	32
Nordic countries	78.2	96.3	41.1	62.8	16.1	34.5	52	65	21	36
Other W. Europe	99.3	136.2	42.1	82.8	22.9	51.9	42	61	23	38
Japan	138.4	200.6	46.0	100.0	8.6	25.5	33	50	6	13
Canada	84.5	103.9	36.1	59.3	15.1	29.5	43	57	18	28
Eastern Europe	57.2	58.1	20.1	32.8	10.0	23.8	35	56	17	41
Former USSR	152.9	134.6	24.3	39.0	4.5	22.9	16	29	3	17
Baltic states	NA	1.9	NA	1.1	NA	1.0	NA	57	NA	51
Russia	NA	59.3	NA	19.5	NA	12.5	NA	33	NA	21
Other former USSR	152.9	73.3	24.3	18.5	4.5	9.4	16	25	3	13
Israel	22.6	25.6	12.2	16.9	5.3	9.4	54	66	24	37
Near East/N. Africa	12.2	17.6	5.3	9.6	3.4	6.5	43	54	28	37
Other Africa	19.5	21.3	8.6	12.8	4.2	8.3	44	60	21	39
India	55.7	43.8	10.8	14.5	3.5	5.9	19	33	6	13
Central America	5.9	9.6	3.2	6.2	2.2	4.4	55	64	37	46
South America	20.2	32.7	9.0	20.4	4.8	13.1	44	62	24	40
Aust. & N. Zealand	52.6	62.6	18.1	31.8	7.3	15.6	34	51	14	25
China	9.1	30.8	3.4	16.1	2.1	8.8	37	52	23	29
Asian NIEs[b]	5.6	37.5	2.4	20.0	1.5	9.1	42	53	27	24
Other Asian/Pacific	5.9	9.2	2.9	6.4	2.3	5.2	50	70	39	57
	Clinical medicine									
World[a]	598.7	664.8	288.4	384.1	28.7	64.1	48	58	5	10
United States	251.4	267.1	141.8	170.0	15.0	32.9	56	64	6	12
United Kingdom	62.8	71.5	26.5	38.9	6.1	12.9	42	54	10	18
Germany	42.6	48.4	16.5	26.0	4.2	10.0	39	54	10	21
France	30.4	36.2	15.8	23.8	3.4	8.0	52	66	11	22
Italy	16.5	26.7	9.3	18.6	2.0	6.2	56	70	12	23
Other S. Europe	6.2	17.7	2.9	10.8	0.9	3.8	47	61	15	21
Nordic countries	40.7	42.3	24.8	30.3	6.3	11.7	61	72	15	28
Other W. Europe	37.6	50.4	18.4	33.9	6.5	15.7	49	67	17	31
Japan	34.8	59.2	14.7	33.2	2.1	6.5	42	56	6	11
Canada	23.5	30.2	13.5	20.7	3.5	7.7	58	68	15	26
Eastern Europe	9.9	7.6	4.2	4.7	1.4	2.9	42	63	15	39
Former USSR	19.3	11.4	4.9	3.7	0.4	1.3	25	33	2	12
Baltic states	NA	0.2	NA	0.1	NA	0.1	NA	69	NA	60
Russia	NA	4.4	NA	1.6	NA	0.6	NA	36	NA	14
Other former USSR	19.3	6.7	4.9	2.0	0.4	0.6	25	30	2	9
Israel	7.8	8.4	5.5	6.4	1.1	1.9	70	77	14	23
Near East/N. Africa	2.8	4.3	1.4	2.6	0.7	1.4	50	61	26	32
Other Africa	8.3	8.1	4.7	5.8	1.6	3.4	57	71	19	41
India	7.1	5.8	2.1	2.6	0.3	0.7	29	45	5	11
Central America	2.1	2.1	1.2	1.5	0.6	0.9	59	69	29	44
South America	5.6	8.4	2.8	5.4	1.1	2.8	50	65	19	34
Aust. & N. Zealand	16.6	20.6	6.8	11.4	1.6	3.9	41	55	10	19
China	1.4	3.1	0.7	1.9	0.3	1.4	48	61	21	43
Asian NIEs[b]	1.1	8.0	0.6	5.2	0.4	1.8	58	65	32	22
Other Asian/Pacific	1.7	2.7	1.0	2.1	0.7	1.6	59	77	40	59

Appendix table 5-53.

Coauthored and internationally coauthored scientific and technical articles for selected countries, by field: 1981-85 and 1991-95

	Number of articles (in thousands)						Percent of total articles			
	Total		Multi-author		Internationally coauthored		Multi-author		Internationally coauthored	
Country	1981-85	1991-95	1981-85	1991-95	1981-85	1991-95	1981-85	1991-95	1981-85	1991-95
					Biomedical research					
World[a]	290.8	351.8	107.4	179.4	20.7	48.4	37	51	7	14
United States	119.0	149.8	54.6	88.7	10.8	25.6	46	59	9	17
United Kingdom	27.1	32.5	9.2	17.2	4.5	9.5	34	53	17	29
Germany	22.3	27.0	8.0	14.7	4.3	9.5	36	54	19	35
France	16.1	22.9	8.0	14.2	3.0	7.3	49	62	19	32
Italy	7.0	11.2	4.0	8.1	1.4	3.7	58	72	21	33
Other S. Europe	4.8	10.3	1.8	5.6	0.7	3.3	38	55	14	32
Nordic countries	12.5	16.4	6.4	11.0	3.1	6.7	51	67	25	41
Other W. Europe	15.8	23.9	7.0	15.0	4.0	9.9	44	62	25	41
Japan	19.8	31.7	7.5	18.3	1.6	5.0	38	58	8	16
Canada	13.4	17.8	5.9	10.8	2.4	5.3	44	61	18	30
Eastern Europe	8.8	8.0	3.4	4.6	1.6	3.2	39	58	19	40
Former USSR	19.6	19.3	4.2	6.4	0.8	3.0	21	33	4	15
Baltic states	NA	0.2	NA	0.2	NA	0.1	NA	68	NA	59
Russia	NA	8.3	NA	3.0	NA	1.6	NA	36	NA	19
Other former USSR	19.6	10.8	4.2	3.3	0.8	1.3	21	30	4	12
Israel	3.6	4.1	1.9	2.7	0.9	1.7	53	66	25	42
Near East/N. Africa	1.0	1.2	0.5	0.7	0.3	0.5	51	62	32	47
Other Africa	2.0	2.8	0.8	1.7	0.5	1.1	42	61	25	41
India	7.3	5.5	1.2	1.8	0.4	0.7	16	32	5	13
Central America	0.8	1.5	0.4	1.0	0.3	0.7	52	66	33	47
South America	3.7	5.4	1.7	3.4	0.8	2.0	45	62	20	37
Aust. & N. Zealand	6.9	9.4	2.4	4.9	1.1	2.7	34	52	16	29
China	0.6	2.4	0.3	1.2	0.2	0.8	47	52	32	35
Asian NIEs[b]	0.4	3.4	0.2	2.1	0.1	1.0	47	62	30	30
Other Asian/Pacific	0.7	1.1	0.4	0.9	0.3	0.7	57	76	44	63
					Biology					
World[a]	189.1	171.7	51.6	69.1	10.5	19.6	27	40	6	11
United States	73.7	62.9	25.7	29.0	5.0	8.3	35	46	7	13
United Kingdom	18.0	14.4	4.2	6.3	2.0	3.5	23	44	11	25
Germany	11.4	9.8	3.0	4.0	1.6	2.5	26	41	14	26
France	6.9	7.6	2.8	4.2	1.1	2.1	40	55	16	28
Italy	2.4	3.3	1.0	1.9	0.4	0.9	43	58	16	28
Other S. Europe	2.2	6.7	0.8	3.1	0.5	1.7	35	46	21	25
Nordic countries	5.6	7.9	1.8	3.6	1.0	2.1	33	46	17	27
Other W. Europe	7.6	8.9	2.2	4.4	1.2	2.8	29	49	16	31
Japan	12.6	13.7	3.7	6.4	0.7	1.6	29	47	6	12
Canada	14.3	14.5	4.4	6.7	1.6	2.8	31	46	11	19
Eastern Europe	5.0	2.9	1.5	1.5	0.7	1.1	30	52	13	37
Former USSR	5.4	4.4	0.9	1.1	0.2	0.5	17	24	3	12
Baltic states	NA	0.1	NA	0.0	NA	0.0	NA	53	NA	47
Russia	NA	2.3	NA	0.5	NA	0.3	NA	23	NA	13
Other former USSR	5.4	2.1	0.9	0.5	0.2	0.2	17	24	3	10
Israel	2.3	2.3	1.0	1.4	0.4	0.8	41	59	19	33
Near East/N. Africa	1.6	1.8	0.7	1.0	0.5	0.8	43	58	29	46
Other Africa	4.4	4.8	1.4	2.5	0.9	1.8	31	52	21	37
India	8.1	3.6	1.1	1.1	0.4	0.5	14	30	5	15
Central America	1.0	1.9	0.5	1.1	0.4	0.8	49	58	42	45
South America	2.8	3.9	1.3	2.3	0.8	1.6	46	59	30	40
Aust. & N. Zealand	11.6	12.4	3.5	5.6	1.2	2.4	30	45	11	19
China	1.2	1.3	0.3	0.9	0.2	0.7	28	65	16	53
Asian NIEs[b]	0.6	2.0	0.2	1.0	0.2	0.6	42	53	32	29
Other Asian/Pacific	1.6	2.3	0.7	1.5	0.6	1.3	45	68	38	59

Appendix table 5-53.

Coauthored and internationally coauthored scientific and technical articles for selected countries, by field: 1981-85 and 1991-95

	Number of articles (in thousands)						Percent of total articles			
	Total		Multi-author		Internationally coauthored		Multi-author		Internationally coauthored	
Country	1981-85	1991-95	1981-85	1991-95	1981-85	1991-95	1981-85	1991-95	1981-85	1991-95
					Chemistry					
World[a]	273.4	296.1	62.4	101.1	15.0	31.5	23	34	5	11
United States	59.1	69.9	16.7	27.1	5.4	10.1	28	39	9	14
United Kingdom	19.0	19.9	5.8	9.3	3.2	5.0	31	47	17	25
Germany	24.7	29.6	6.7	11.8	3.4	6.7	27	40	14	23
France	16.6	20.4	6.4	10.7	2.6	5.7	39	52	16	28
Italy	8.6	10.5	4.2	6.6	1.3	2.7	49	63	15	26
Other S. Europe	7.8	15.5	2.7	7.8	1.1	4.5	35	50	14	29
Nordic countries	5.7	7.8	2.1	4.1	1.2	2.8	36	53	21	36
Other W. Europe	12.1	15.4	3.6	7.2	2.3	4.9	30	47	19	32
Japan	29.6	33.6	7.1	12.4	1.1	2.6	24	37	4	8
Canada	9.1	10.0	2.7	4.0	1.7	2.5	30	39	18	25
Eastern Europe	17.2	16.8	5.5	8.2	2.5	5.0	32	49	14	30
Former USSR	46.7	35.2	7.0	7.8	1.0	3.6	15	22	2	10
Baltic states	NA	0.4	NA	0.2	NA	0.2	NA	43	NA	38
Russia	NA	15.6	NA	3.8	NA	1.8	NA	24	NA	12
Other former USSR	46.7	19.2	7.0	3.9	1.0	1.6	15	20	2	8
Israel	2.0	1.9	0.7	1.1	0.5	0.7	37	56	23	39
Near East/N. Africa	3.2	4.7	1.1	2.2	0.6	1.5	34	47	20	31
Other Africa	1.7	1.8	0.6	0.8	0.4	0.6	34	45	23	32
India	15.3	12.4	2.0	2.8	0.7	1.0	13	22	4	8
Central America	0.6	1.0	0.3	0.7	0.2	0.4	54	64	44	41
South America	2.5	3.9	0.7	2.1	0.4	1.3	30	54	17	34
Aust. & N. Zealand	5.4	5.5	1.6	2.6	0.8	1.4	30	47	15	25
China	0.8	6.1	0.3	2.4	0.2	1.1	33	39	22	18
Asian NIEs[b]	1.1	7.4	0.3	3.2	0.2	1.2	27	44	15	17
Other Asian/Pacific	0.6	1.2	0.2	0.7	0.2	0.5	41	61	35	45
					Physics					
World[a]	240.2	339.4	68.1	148.8	23.3	63.7	28	44	10	19
United States	73.2	102.7	29.2	56.1	10.6	25.7	40	55	14	25
United Kingdom	16.6	22.8	5.6	12.5	4.0	9.1	34	55	24	40
Germany	22.6	37.7	8.8	21.1	6.2	16.3	39	56	27	43
France	17.3	26.8	8.4	17.6	4.9	12.2	49	66	28	45
Italy	8.0	15.5	5.6	12.0	2.5	7.8	70	78	32	50
Other S. Europe	4.6	13.1	2.3	8.7	1.4	6.7	49	66	31	51
Nordic countries	6.7	11.9	3.4	8.2	2.8	7.0	51	69	42	59
Other W. Europe	14.9	23.3	6.8	14.6	5.8	12.6	46	63	39	54
Japan	20.8	40.1	6.2	19.2	1.5	6.0	30	48	7	15
Canada	8.4	12.1	3.4	7.0	2.2	5.0	40	58	26	41
Eastern Europe	9.2	15.4	3.5	9.8	2.3	8.4	38	64	25	55
Former USSR	40.2	47.8	3.9	14.8	1.5	11.1	10	31	4	23
Baltic states	NA	0.7	NA	0.4	NA	0.4	NA	56	NA	51
Russia	NA	21.4	NA	8.0	NA	6.3	NA	37	NA	30
Other former USSR	40.2	25.6	3.9	6.4	1.5	4.4	10	25	4	17
Israel	3.3	5.1	1.6	3.2	1.3	2.6	49	63	38	51
Near East/N. Africa	1.1	2.3	0.5	1.3	0.4	1.0	46	57	35	44
Other Africa	0.8	1.3	0.3	0.7	0.2	0.5	40	56	31	42
India	8.9	9.1	2.1	3.7	0.8	1.8	24	40	9	20
Central America	0.8	1.8	0.5	1.1	0.3	0.8	55	63	39	45
South America	3.0	6.8	1.2	4.4	0.8	3.2	41	64	25	47
Aust. & N. Zealand	3.8	5.5	1.1	2.6	0.7	1.9	28	47	18	35
China	2.1	11.2	0.7	6.7	0.4	2.7	33	60	19	24
Asian NIEs[b]	0.9	7.6	0.4	4.3	0.2	2.1	40	57	25	28
Other Asian/Pacific	0.5	0.8	0.2	0.5	0.1	0.4	38	62	31	52

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Appendix table 5-53.

Coauthored and internationally coauthored scientific and technical articles for selected countries, by field: 1981-85 and 1991-95

	Number of articles (in thousands)						Percent of total articles			
	Total		Multi-author		Internationally coauthored		Multi-author		Internationally coauthored	
Country	1981-85	1991-95	1981-85	1991-95	1981-85	1991-95	1981-85	1991-95	1981-85	1991-95
Earth and space sciences										
World[a]	84.3	107.2	29.5	53.4	9.5	21.8	35	50	11	20
United States	38.3	49.1	17.0	28.6	5.5	11.9	45	58	14	24
United Kingdom	8.5	11.0	3.5	6.5	2.4	4.8	41	60	28	43
Germany	5.1	7.7	2.4	4.9	1.8	4.0	46	63	35	52
France	4.4	7.2	2.5	5.2	1.5	3.7	56	73	33	51
Italy	2.0	4.1	1.3	3.2	0.8	2.0	64	78	37	50
Other S. Europe	1.2	4.2	0.6	2.6	0.5	1.8	53	63	40	44
Nordic countries	2.5	5.1	1.2	3.3	0.9	2.5	48	64	35	48
Other W. Europe	3.6	6.2	1.8	3.9	1.4	3.2	49	64	40	52
Japan	2.4	5.0	1.1	3.1	0.4	1.6	46	62	18	32
Canada	5.6	8.8	2.5	5.2	1.4	3.2	45	59	26	36
Eastern Europe	1.4	2.0	0.5	1.2	0.4	1.0	38	61	25	51
Former USSR	8.3	7.1	1.5	2.7	0.4	1.9	19	38	5	27
Baltic states	NA	0.1	NA	0.1	NA	0.1	NA	68	NA	63
Russia	NA	3.4	NA	1.4	NA	1.1	NA	42	NA	32
Other former USSR	8.3	3.5	1.5	1.2	0.4	0.7	19	34	5	21
Israel	0.8	1.2	0.4	0.7	0.3	0.5	53	63	37	46
Near East/N. Africa	0.5	0.9	0.2	0.5	0.2	0.4	51	56	42	42
Other Africa	1.0	1.7	0.4	0.9	0.3	0.7	38	55	30	39
India	2.6	2.5	0.6	0.9	0.3	0.5	23	37	11	21
Central America	0.3	0.7	0.2	0.5	0.2	0.4	59	71	53	61
South America	1.1	2.2	0.6	1.6	0.5	1.4	54	73	47	60
Aust. & N. Zealand	3.9	4.9	1.5	2.9	1.0	2.0	38	58	25	40
China	1.4	1.4	0.4	0.9	0.2	0.7	31	66	18	52
Asian NIEs[b]	0.1	1.0	0.1	0.6	0.1	0.4	52	61	45	44
Other Asian/Pacific	0.2	0.5	0.1	0.3	0.1	0.3	60	71	55	64
Engineering and technology										
World[a]	149.7	146.4	38.2	52.7	8.0	15.4	25	36	5	11
United States	62.2	54.9	19.2	23.5	4.4	7.5	31	43	7	14
United Kingdom	12.9	11.2	3.0	4.2	1.6	2.3	23	37	12	20
Germany	11.8	11.1	2.9	4.3	1.3	2.5	25	39	11	22
France	5.2	7.2	1.8	3.7	0.8	1.9	35	51	15	27
Italy	2.5	4.0	1.0	2.2	0.3	1.1	40	54	14	27
Other S. Europe	2.1	4.9	0.7	2.3	0.4	1.4	33	47	21	29
Nordic countries	3.2	3.8	0.9	1.7	0.5	1.2	28	46	17	31
Other W. Europe	5.4	5.9	1.6	2.7	1.1	1.9	30	46	20	33
Japan	15.8	15.6	5.2	6.8	0.8	1.9	33	44	5	12
Canada	7.2	8.0	2.4	3.6	1.3	2.0	34	45	18	25
Eastern Europe	3.6	3.6	1.0	1.7	0.6	1.3	28	48	17	37
Former USSR	10.6	7.9	1.7	2.1	0.2	1.0	16	26	2	13
Baltic states	NA	0.1	NA	0.0	NA	0.0	NA	50	NA	45
Russia	NA	3.3	NA	1.0	NA	0.6	NA	29	NA	17
Other former USSR	10.6	4.4	1.7	1.1	0.2	0.4	16	24	2	10
Israel	1.8	1.6	0.7	0.8	0.4	0.6	37	50	25	36
Near East/N. Africa	1.6	2.2	0.7	1.0	0.5	0.8	43	46	34	35
Other Africa	1.0	0.7	0.3	0.3	0.2	0.2	29	40	16	28
India	4.8	4.5	1.3	1.5	0.4	0.5	27	34	9	12
Central America	0.2	0.3	0.1	0.2	0.1	0.1	52	57	45	43
South America	0.9	1.3	0.4	0.8	0.3	0.5	47	58	29	38
Aust. & N. Zealand	3.1	3.1	0.8	1.3	0.5	0.9	26	42	15	27
China	1.0	4.0	0.4	1.7	0.4	1.0	41	42	34	26
Asian NIEs[b]	1.1	7.3	0.4	3.2	0.3	1.6	39	43	28	22
Other Asian/Pacific	0.4	0.4	0.2	0.3	0.1	0.2	44	62	40	51

Appendix table 5-53.
Coauthored and internationally coauthored scientific and technical articles for selected countries, by field: 1981-85 and 1991-95

	Number of articles (in thousands)						Percent of total articles			
	Total		Multi-author		Internationally coauthored		Multi-author		Internationally coauthored	
Country	1981-85	1991-95	1981-85	1991-95	1981-85	1991-95	1981-85	1991-95	1981-85	1991-95
					Mathematics					
World[a]	48.1	39.8	11.5	14.4	5.2	7.4	24	36	11	19
United States	20.0	17.3	7.2	8.1	3.2	4.1	36	47	16	24
United Kingdom	3.6	2.9	1.1	1.3	0.9	1.0	31	45	25	36
Germany	4.5	3.3	1.0	1.4	0.8	1.2	22	42	18	36
France	3.4	4.0	1.0	1.8	0.7	1.2	30	46	21	29
Italy	1.0	1.6	0.4	0.9	0.3	0.6	41	56	27	39
Other S. Europe	1.0	1.7	0.2	0.8	0.2	0.7	25	49	19	39
Nordic countries	1.3	1.2	0.4	0.6	0.4	0.5	33	49	28	41
Other W. Europe	2.3	2.2	0.7	1.1	0.6	0.9	31	49	26	42
Japan	2.6	1.7	0.5	0.6	0.3	0.3	20	35	12	19
Canada	2.9	2.5	1.2	1.4	1.0	1.2	43	56	37	47
Eastern Europe	2.0	1.7	0.6	0.9	0.5	0.8	29	52	23	47
Former USSR	2.9	1.6	0.3	0.4	0.1	0.4	9	27	3	22
Baltic states	NA	0.0	NA	0.0	NA	0.0	NA	75	NA	63
Russia	NA	0.6	NA	0.2	NA	0.2	NA	37	NA	33
Other former USSR	2.9	1.0	0.3	0.2	0.1	0.1	9	19	3	15
Israel	1.0	1.0	0.5	0.6	0.4	0.5	47	60	41	55
Near East/N. Africa	0.4	0.3	0.2	0.2	0.2	0.2	35	48	34	45
Other Africa	0.3	0.2	0.1	0.1	0.1	0.1	29	48	25	37
India	1.7	0.5	0.4	0.2	0.2	0.2	26	42	14	31
Central America	0.1	0.2	0.1	0.1	0.0	0.1	44	57	38	43
South America	0.5	0.8	0.2	0.4	0.2	0.3	46	58	38	46
Aust. & N. Zealand	1.2	1.1	0.4	0.6	0.4	0.5	36	55	30	49
China	0.5	1.3	0.3	0.5	0.2	0.4	48	43	43	34
Asian NIEs[b]	0.3	0.8	0.1	0.4	0.1	0.3	43	47	35	38
Other Asian/Pacific	0.1	0.2	0.1	0.1	0.1	0.1	39	58	39	55

NA = not available; NIEs = newly industrialized economies

NOTE: Details may not add to totals because of rounding.

[a] International collaboration rates for the entire world cannot be compared to country rates because, regardless of the number of countries involved, an internationally coauthored article is counted only once.

[b] Data for Hong Kong are included with United Kingdom through 1986.

SOURCE: Institute for Scientific Information, Science Citation Index; CHI Research Inc., Science Indicators database; and National Science Foundation, unpublished tabulations.

Appendix table 5-54.

Patterns of international coauthorship in scientific and technical research: 1981-85 and 1991-95

(Percentages)

Code	Country/region	Collaborating country (by country code)																
		1981-85																
		1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	17	19
	Articles (thousands)	697.9	84.5	168.5	100.4	145.0	11.8	19.2	3.8	0.1	35.4	29.1	48.0	4.9	1.4	16.7	1.6	18.1
	Multi-author (%)	45	43	35	46	34	42	45	42	58	41	43	56	37	52	37	46	53
	International (%)	9	18	15	18	16	20	24	23	46	19	29	19	23	39	13	31	23
1	United States		12	13	7	11	1	2	0	0	3	4	4	1	0	1	0	2
2	Canada	47		10	8	4	0	1	0	0	2	2	1	0	0	0	0	1
3	United Kingdom	28	6		7	8	1	2	1	0	4	3	5	1	1	1	0	2
4	France	23	6	9		10	1	5	0	0	3	6	7	1	1	2	0	1
5	Germany	25	2	9	8		3	2	0	0	4	7	4	1	0	1	0	2
6	Austria	16	2	8	5	28		2	0	0	3	8	5	0	0	1	0	1
7	Belgium	19	3	9	18	9	1		0	0	9	5	5	0	0	2	0	1
8	Ireland	17	6	38	7	5	0	3		0	3	1	4	0	0	1	0	1
9	Luxembourg	0	1	7	29	14	1	10	6		9	3	10	0	0	0	0	4
10	Netherlands	24	3	13	8	12	1	6	0	0		4	5	0	0	1	0	2
11	Switzerland	22	2	9	11	18	2	3	0	0	3		9	1	0	1	0	2
13	Italy	25	2	13	13	9	1	2	0	0	4	8		0	0	2	0	1
14	Greece	31	4	18	9	11	1	2	0	0	2	5	2		0	1	0	1
15	Portugal	22	2	25	17	7	0	1	1	0	2	2	2	0		2	0	1
16	Spain	20	2	13	20	8	1	4	0	0	3	4	8	0	0		0	1
17	Turkey	36	3	18	4	17	1	2	0	0	1	1	3	1	0	1		1
19	Denmark	22	4	12	5	9	1	1	0	0	3	4	2	0	0	1	0	
20	Finland	23	4	9	5	8	1	2	0	0	3	3	2	0	0	0	0	4
21	Norway	22	3	12	4	9	1	2	0	0	2	2	2	0	1	0	0	9
22	Sweden	26	2	9	5	9	1	2	0	0	3	4	4	0	0	1	0	9
23	Iceland	26	6	21	3	6	0	0	0	0	1	1	0	0	0	0	0	11
24	Bulgaria	4	1	3	6	22	3	1	0	0	1	0	3	1	0	0	0	1
25	Hungary	18	3	6	5	19	3	2	0	0	3	2	4	0	0	0	0	1
26	Poland	17	4	8	10	19	1	2	0	0	3	4	5	0	0	1	0	1
27	Czechoslovakia	6	2	4	5	20	1	2	0	0	2	1	3	0	0	0	0	1
28	Czech Republic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
29	Slovakia	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
31	USSR	8	1	2	6	25	1	1	0	0	2	2	3	0	0	0	0	2
32	Russia	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
33	Ukraine	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
34	Baltic states	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
36	Japan	49	5	6	4	9	1	1	0	0	2	2	1	0	0	0	0	1
37	China	48	5	7	7	8	0	1	0	0	1	2	2	0	0	1	0	0
38	Taiwan	51	6	4	0	4	0	0	0	0	0	0	0	0	0	0	0	0
39	South Korea	57	5	3	2	5	0	1	0	0	0	1	1	0	0	0	0	0
40	Singapore	21	7	16	2	1	0	0	0	0	0	2	0	0	0	0	0	0

Appendix table 5-54.

Patterns of international coauthorship in scientific and technical research: 1981-85 and 1991-95

(Percentages)

Code	Country/region	Collaborating country (by country code)																
		1981-85																
		1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	17	19
41	Hong Kong	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
42	India	34	9	12	4	10	0	1	0	0	2	2	3	0	0	0	0	1
44	Australia	33	7	21	4	5	1	1	0	0	2	2	1	0	0	0	0	2
45	New Zealand	29	8	18	2	5	1	1	0	0	1	1	1	0	0	0	0	1
46	Israel	55	3	7	5	11	0	1	0	0	2	3	2	0	0	0	0	1
48	Argentina	32	3	8	9	10	0	1	0	0	2	1	4	0	0	2	0	1
49	Brazil	37	6	9	10	8	0	1	0	0	1	2	4	0	0	1	0	1
50	Chile	37	5	7	7	8	0	1	0	0	2	1	2	0	0	7	0	1
52	Mexico	51	6	5	8	5	0	1	0	0	0	2	2	0	0	4	0	0
54	Egypt	31	4	13	7	12	1	1	0	0	1	1	1	0	0	0	0	2
56	South Africa	30	5	20	3	10	0	1	0	0	2	2	1	0	0	0	0	1

Code	Country/region	1981-85																
		20	21	22	23	24	25	26	27	28	29	31	32	33	34	36	37	38
	Articles (thousands)	13.4	11.2	35.3	0.3	5.5	11.4	20.6	16.5	NA	NA	152.9	NA	NA	NA	138.4	9.1	2.8
	Multi-author (%)	50	49	54	58	33	44	31	36	NA	NA	16	NA	NA	NA	33	37	43
	International (%)	17	21	20	44	19	21	18	15	NA	NA	3	NA	NA	NA	6	23	26
1	United States	1	1	3	0	0	1	1	0	0	0	1	0	0	0	7	2	1
2	Canada	1	1	1	0	0	1	1	0	0	0	0	0	0	0	3	1	0
3	United Kingdom	1	1	3	0	0	1	1	0	0	0	0	0	0	0	2	1	0
4	France	1	1	2	0	0	1	2	1	0	0	1	0	0	0	2	1	0
5	Germany	1	1	3	0	1	2	3	2	0	0	5	0	0	0	3	1	0
6	Austria	1	1	2	0	1	2	2	1	0	0	2	0	0	0	2	0	0
7	Belgium	1	1	3	0	0	1	1	1	0	0	1	0	0	0	2	0	0
8	Ireland	1	1	2	0	0	0	1	0	0	0	0	0	0	0	1	0	0
9	Luxembourg	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Netherlands	1	1	3	0	0	1	2	1	0	0	1	0	0	0	2	0	0
11	Switzerland	1	1	3	0	0	1	1	0	0	0	1	0	0	0	2	0	0
13	Italy	1	1	3	0	0	1	2	1	0	0	2	0	0	0	1	0	0
14	Greece	1	0	2	0	1	0	0	1	0	0	1	0	0	0	1	0	0
15	Portugal	1	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	Spain	0	0	2	0	0	0	1	0	0	0	1	0	0	0	1	1	0
17	Turkey	0	0	2	0	0	0	0	1	0	0	0	0	0	0	2	0	0
19	Denmark	2	5	15	0	0	1	1	0	0	0	1	0	0	0	1	0	0
20	Finland		3	16	0	0	1	1	2	0	0	4	0	0	0	1	0	0
21	Norway	3		16	0	0	0	2	1	0	0	1	0	0	0	1	0	0
22	Sweden	5	6		0	0	1	2	1	0	0	1	0	0	0	2	1	0
23	Iceland	4	4	15		0	0	0	0	0	0	0	0	0	0	0	0	0
24	Bulgaria	0	0	1	0		3	5	7	0	0	31	0	0	0	1	0	0

Appendix table 5-54.

Patterns of international coauthorship in scientific and technical research: 1981-85 and 1991-95

(Percentages)

		Collaborating country (by country code)																
		1981-85																
Code	Country/region	20	21	22	23	24	25	26	27	28	29	31	32	33	34	36	37	38
25	Hungary	1	0	2	0	1		3	5	0	0	12	0	0	0	2	0	0
26	Poland	1	1	4	0	1	2		4	0	0	5	0	0	0	1	0	0
27	Czechoslovakia	2	1	2	0	3	5	6		0	0	25	0	0	0	1	0	0
28	Çzech Republic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
29	Slovakia	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
31	USSR	2	1	2	0	7	6	5	13	0	0		0	0	0	1	0	0
32	Russia	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
33	Ukraine	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
34	Baltic states	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
36	Japan	0	0	2	0	0	1	1	0	0	0	1	0	0	0		2	2
37	China	0	0	2	0	0	0	0	0	0	0	0	0	0	0	8		0
38	Taiwan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	1	
39	South Korea	0	0	1	0	0	0	0	0	0	0	0	0	0	0	18	0	0
40	Singapore	0	0	2	0	0	1	0	0	0	0	0	0	0	0	3	0	0
41	Hong Kong	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
42	India	0	0	2	0	0	0	0	1	0	0	1	0	0	0	5	0	0
44	Australia	1	0	2	0	0	0	0	0	0	0	0	0	0	0	2	1	0
45	New Zealand	0	1	1	0	0	0	1	0	0	0	0	0	0	0	2	0	0
46	Israel	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0
48	Argentina	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	Brazil	0	0	1	0	0	0	1	0	0	0	0	0	0	0	2	0	0
50	Chile	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
52	Mexico	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0
54	Egypt	0	1	1	0	0	1	1	1	0	0	1	0	0	0	2	0	0
56	South Africa	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0

		1981-85												
Code	Country/region	39	40	41	42	44	45	46	48	49	50	52	54	56
	Articles (thousands)	1.7	1.1	NA	55.7	43.2	9.4	22.6	5.6	8.3	3.3	4.0	5.6	9.9
	Multi-author (%)	44	35	NA	19	35	32	54	35	47	44	55	40	47
	International (%)	31	22	NA	6	14	15	24	13	25	22	31	20	14
1	United States	1	0	0	2	3	1	5	0	1	1	1	1	1
2	Canada	0	0	0	2	3	1	1	0	1	0	1	0	0
3	United Kingdom	0	0	0	2	5	1	2	0	1	0	0	1	1
4	France	0	0	0	1	1	0	1	0	1	0	1	0	0
5	Germany	0	0	0	1	1	0	2	0	1	0	0	1	1
6	Austria	0	0	0	1	2	0	1	0	0	0	0	0	0

Appendix table 5-54.

Patterns of international coauthorship in scientific and technical research: 1981-85 and 1991-95

(Percentages)

		Collaborating country (by country code)												
		1981-85												
Code	Country/region	39	40	41	42	44	45	46	48	49	50	52	54	56
7	Belgium	0	0	0	1	1	0	1	0	0	0	0	0	0
8	Ireland	0	0	0	1	2	0	1	0	0	0	0	0	0
9	Luxembourg	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Netherlands	0	0	0	1	1	0	2	0	0	0	0	0	0
11	Switzerland	0	0	0	1	1	0	2	0	0	0	0	0	0
13	Italy	0	0	0	1	1	0	1	0	1	0	0	0	0
14	Greece	0	0	0	0	1	0	1	0	0	0	0	0	0
15	Portugal	0	0	0	0	1	0	1	0	1	0	0	0	0
16	Spain	0	0	0	0	1	0	0	1	1	2	2	0	0
17	Turkey	0	0	0	1	0	0	1	0	0	0	0	0	0
19	Denmark	0	0	0	1	2	0	1	0	0	0	0	0	0
20	Finland	0	0	0	0	2	0	1	0	0	0	0	0	0
21	Norway	0	0	0	1	1	0	1	0	0	0	0	0	0
22	Sweden	0	0	0	1	1	0	1	0	0	0	0	0	0
23	Iceland	0	0	0	0	1	0	0	0	0	0	0	0	0
24	Bulgaria	0	0	0	1	0	0	0	0	0	0	0	0	0
25	Hungary	0	0	0	0	1	0	0	0	0	0	0	0	0
26	Poland	0	0	0	0	1	0	0	0	0	0	0	0	0
27	Czechoslovakia	0	0	0	1	0	0	0	0	0	0	0	0	0
28	Czech Republic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
29	Slovakia	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
31	USSR	0	0	0	1	0	0	0	0	0	0	0	0	0
32	Russia	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
33	Ukraine	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
34	Baltic states	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
36	Japan	1	0	0	2	2	0	1	0	1	0	0	0	0
37	China	0	0	0	0	3	0	0	0	0	0	0	0	0
38	Taiwan	0	0	0	1	0	0	1	0	0	0	0	0	1
39	South Korea		0	0	0	0	0	0	0	0	0	0	0	0
40	Singapore	0		0	6	12	1	0	0	1	1	1	1	1
41	Hong Kong	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
42	India	0	0	0		3	0	1	0	1	0	0	0	0
44	Australia	0	1	0	1		5	1	0	0	0	0	0	1
45	New Zealand	0	0	0	1	21		0	0	0	0	0	0	1
46	Israel	0	0	0	0	1	0		0	0	0	0	0	1
48	Argentina	0	0	0	0	1	0	1		10	3	2	0	0
49	Brazil	0	0	0	1	1	0	1	3		1	1	0	0

Appendix table 5-54.

Patterns of international coauthorship in scientific and technical research: 1981-85 and 1991-95

(Percentages)

		Collaborating country (by country code)												
		1981-85												
Code	Country/region	**39**	**40**	**41**	**42**	**44**	**45**	**46**	**48**	**49**	**50**	**52**	**54**	**56**
50	Chile	0	0	0	1	3	0	1	3	4		1	0	0
52	Mexico	0	0	0	1	0	0	0	1	2	1		0	0
54	Egypt	0	0	0	1	0	0	0	0	0	0	0		0
56	South Africa	0	0	0	0	5	1	6	0	0	0	0	0	

		1991-95																
Code	Country/region	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**13**	**14**	**15**	**16**	**17**	**19**
	Articles (thousands)	773.7	103.9	186.2	132.2	174.6	16.1	24.1	5.0	0.1	52.7	38.1	76.9	9.3	4.5	46.1	5.8	21.9
	Multi-author (%)	56	57	52	61	50	61	64	59	71	61	59	70	57	67	54	53	65
	International (%)	16	28	26	32	30	37	42	38	67	31	45	33	37	48	29	25	39
1	United States		10	10	8	10	1	2	0	0	3	3	5	1	0	2	0	2
2	Canada	41		8	8	5	1	1	0	0	2	2	3	0	0	1	0	1
3	United Kingdom	23	4		7	8	1	2	1	0	4	3	6	1	1	4	0	2
4	France	20	5	8		10	1	4	0	0	3	5	6	1	1	5	0	1
5	Germany	22	3	7	8		3	2	0	0	4	6	5	1	0	2	0	2
6	Austria	16	2	6	6	24		1	0	0	3	6	4	1	0	2	0	2
7	Belgium	15	2	9	16	9	1		1	0	9	4	5	1	1	3	0	1
8	Ireland	16	4	27	6	8	1	3		0	4	3	4	1	1	3	0	2
9	Luxembourg	6	1	7	17	10	1	15	2		4	5	9	4	1	3	0	4
10	Netherlands	19	3	11	8	12	1	6	0	0		4	5	1	1	3	0	2
11	Switzerland	19	3	8	11	16	2	2	0	0	4		8	1	1	2	0	1
13	Italy	22	3	10	10	9	1	2	0	0	3	6		1	1	4	0	2
14	Greece	17	3	12	11	11	2	3	0	0	2	5	5		2	3	0	2
15	Portugal	12	2	14	12	8	1	4	0	0	4	4	6	3		6	0	1
16	Spain	18	2	12	15	9	1	2	0	0	3	3	8	1	1		0	2
17	Turkey	25	2	14	4	13	1	2	0	0	3	4	5	1	0	2		1
19	Denmark	18	3	11	6	10	1	2	0	0	4	3	4	1	0	2	0	
20	Finland	19	3	7	5	8	1	2	0	0	3	3	3	1	1	2	0	4
21	Norway	18	3	8	6	7	1	2	0	0	3	3	3	2	1	2	0	7
22	Sweden	20	3	8	5	8	1	2	0	0	3	3	4	1	1	2	0	7
23	Iceland	22	2	10	4	5	1	2	0	0	2	1	1	1	1	0	0	13
24	Bulgaria	10	2	4	7	19	2	1	0	0	2	3	7	2	0	4	0	1
25	Hungary	22	3	7	7	16	3	2	0	0	3	4	5	0	0	1	0	1
26	Poland	17	3	6	9	16	1	2	0	0	3	3	6	1	1	2	0	2
27	Czechoslovakia	11	3	6	7	18	3	2	0	0	3	3	4	1	0	2	0	2
28	Czech Republic	11	2	7	9	15	3	3	0	0	3	3	6	2	1	2	0	1
29	Slovakia	9	2	5	8	12	4	4	0	0	2	3	4	2	1	1	0	1

Appendix table 5-54.

Patterns of international coauthorship in scientific and technical research: 1981-85 and 1991-95

(Percentages)

		Collaborating country (by country code)																
		1991-95																
Code	Country/region	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**13**	**14**	**15**	**16**	**17**	**19**
31	USSR	17	2	5	7	19	1	1	0	0	2	3	6	1	0	2	0	1
32	Russia	16	3	5	8	15	1	2	0	0	2	3	5	1	0	1	0	1
33	Ukraine	8	2	3	5	10	1	1	0	0	3	1	4	1	0	2	1	1
34	Baltic states	9	3	4	4	13	0	1	0	0	2	1	4	0	0	1	0	1
36	Japan	40	5	7	4	7	1	1	0	0	2	2	3	0	0	1	0	1
37	China	28	6	7	5	9	1	1	0	0	2	2	5	1	0	1	0	1
38	Taiwan	62	3	3	2	3	0	0	0	0	0	1	1	0	0	0	0	0
39	South Korea	50	3	3	3	4	0	0	0	0	1	1	2	0	0	1	0	0
40	Singapore	22	5	17	2	3	0	1	0	0	1	2	1	0	0	0	0	1
41	Hong Kong	23	6	16	1	3	1	0	0	0	0	1	1	0	0	0	0	0
42	India	28	6	10	5	10	1	1	0	0	2	2	5	0	0	1	0	1
44	Australia	29	6	16	4	7	1	1	0	0	2	2	2	0	0	1	0	1
45	New Zealand	28	7	14	3	6	1	1	0	0	2	1	1	0	0	0	0	1
46	Israel	45	4	6	7	11	1	1	0	0	2	3	4	0	0	1	0	1
48	Argentina	25	3	4	10	9	1	1	0	0	1	1	5	0	0	11	0	1
49	Brazil	27	4	9	10	7	0	2	0	0	1	3	6	1	2	3	0	1
50	Chile	31	4	5	7	8	0	2	0	0	2	1	4	0	0	8	0	0
52	Mexico	35	4	5	8	5	0	1	0	0	1	2	3	0	0	7	0	0
54	Egypt	28	4	8	4	10	2	1	0	0	2	1	4	0	0	1	1	1
56	South Africa	24	5	15	3	11	1	2	0	0	2	2	3	1	0	2	0	1

		1991-95																
Code	Country/region	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**31**	**32**	**33**	**34**	**36**	**37**	**38**
	Articles (thousands)	17.9	13.1	42.7	0.7	5.9	10.1	22.9	9.3	4.4	2.3	58.4	59.3	8.8	1.9	200.6	30.8	17.0
	Multi-author (%)	66	64	65	70	50	67	54	52	61	59	23	33	32	57	50	52	51
	International (%)	32	36	36	54	33	49	42	33	46	41	9	21	25	51	13	29	18
1	United States	1	1	3	0	0	1	2	0	0	0	1	2	0	0	8	2	1
2	Canada	1	1	2	0	0	1	1	0	0	0	0	1	0	0	4	2	0
3	United Kingdom	1	1	3	0	0	1	1	0	0	0	1	1	0	0	3	1	0
4	France	1	1	2	0	0	1	2	0	1	0	1	2	0	0	2	1	0
5	Germany	1	1	3	0	1	2	3	1	1	0	2	4	0	0	3	1	0
6	Austria	1	1	2	0	0	2	2	1	1	1	1	1	0	0	2	2	0
7	Belgium	1	1	3	0	0	1	2	0	1	0	1	2	0	0	2	1	0
8	Ireland	1	1	2	0	0	1	1	0	0	0	0	2	0	0	2	1	0
9	Luxembourg	2	1	0	0	0	1	1	0	1	0	0	0	0	0	1	0	0
10	Netherlands	1	1	3	0	0	1	2	0	0	0	1	2	0	0	3	1	0
11	Switzerland	1	1	2	0	0	1	2	0	0	0	1	2	0	0	2	1	0
13	Italy	1	1	2	0	0	1	2	0	0	0	1	3	0	0	2	1	0

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Appendix table 5-54.

Patterns of international coauthorship in scientific and technical research: 1981-85 and 1991-95

(Percentages)

		Collaborating country (by country code)																
		1991-95																
Code	Country/region	20	21	22	23	24	25	26	27	28	29	31	32	33	34	36	37	38
14	Greece	2	2	2	0	1	0	2	0	1	0	1	2	0	0	1	2	0
15	Portugal	2	2	3	0	0	1	2	0	1	0	1	2	0	0	1	0	0
16	Spain	1	1	2	0	0	0	1	0	0	0	1	1	0	0	1	1	0
17	Turkey	1	0	1	0	1	0	1	0	0	0	0	2	1	0	2	0	0
19	Denmark	3	4	11	1	0	1	2	1	0	0	1	2	0	0	2	1	0
20	Finland		3	10	0	0	2	2	0	1	0	2	4	0	1	3	1	0
21	Norway	3		12	1	0	1	2	1	1	0	1	2	0	0	2	1	0
22	Sweden	4	4		0	0	1	2	1	0	0	1	2	0	1	3	1	0
23	Iceland	5	9	12		0	0	0	0	0	0	0	0	0	0	2	1	0
24	Bulgaria	1	0	2	0		2	3	2	1	0	8	6	1	0	3	0	0
25	Hungary	3	1	3	0	1		1	1	0	0	2	2	0	0	3	1	0
26	Poland	2	1	4	0	1	1		1	1	1	2	4	1	0	2	0	0
27	Czechoslovakia	1	1	3	0	1	2	4		1	0	10	3	0	0	2	0	0
28	Czech Republic	2	2	2	0	1	1	3	1		4	0	6	1	0	2	0	0
29	Slovakia	2	2	4	0	0	1	5	1	8		0	7	2	0	2	1	0
31	USSR	2	1	3	0	3	2	4	5	0	0		0	0	0	2	1	0
32	Russia	2	1	3	0	1	1	3	1	1	1	0		5	1	3	1	0
33	Ukraine	1	0	2	0	1	1	7	1	1	2	0	29		1	2	0	1
34	Baltic states	8	2	14	0	1	0	3	0	1	0	0	16	2		1	0	0
36	Japan	1	0	2	0	0	1	1	0	0	0	0	2	0	0		4	1
37	China	1	0	2	0	0	1	1	0	0	0	0	1	0	0	11		1
38	Taiwan	0	0	1	0	0	0	0	0	0	0	0	1	0	0	8	3	
39	South Korea	0	0	1	0	0	0	1	0	0	0	0	2	0	0	19	2	1
40	Singapore	1	0	2	0	0	0	0	0	0	0	0	0	0	0	7	6	3
41	Hong Kong	0	0	2	0	0	0	0	0	0	0	0	0	0	0	3	20	4
42	India	1	0	1	0	0	1	1	0	0	0	1	1	0	0	5	1	0
44	Australia	0	0	3	0	0	0	1	0	0	0	0	1	0	0	4	2	0
45	New Zealand	1	1	2	0	0	0	1	0	0	0	0	0	0	0	4	1	0
46	Israel	0	0	1	0	0	0	1	0	0	0	1	2	0	0	2	0	0
48	Argentina	1	0	3	0	0	0	1	0	0	0	0	0	0	0	1	0	0
49	Brazil	1	1	1	0	0	0	1	0	1	0	0	2	0	0	3	1	0
50	Chile	0	0	2	0	0	0	1	0	0	0	0	0	0	0	1	1	0
52	Mexico	0	0	1	0	0	0	1	0	0	0	0	3	1	0	1	1	0
54	Egypt	1	0	1	0	0	1	1	0	0	0	1	1	0	0	4	1	0
56	South Africa	1	0	1	0	0	0	2	0	0	0	0	1	0	0	2	0	1

Appendix table 5-54.

Patterns of international coauthorship in scientific and technical research: 1981-85 and 1991-95

(Percentages)

Code	Country/region	Collaborating country (by country code)												
		1991-95												
		39	40	41	42	44	45	46	48	49	50	52	54	56
	Articles (thousands)	11.5	3.9	5.1	43.8	52.2	10.4	25.6	8.3	15.7	4.5	7.2	6.7	10.9
	Multi-author (%)	60	43	56	33	51	50	66	55	63	65	62	49	53
	International (%)	28	26	35	13	24	28	37	31	40	40	41	27	22
1	United States	1	0	0	1	3	1	4	1	2	1	1	0	1
2	Canada	0	0	0	1	3	1	1	0	1	0	0	0	0
3	United Kingdom	0	0	1	1	4	1	1	0	1	0	0	0	1
4	France	0	0	0	1	1	0	1	1	2	0	1	0	0
5	Germany	0	0	0	1	2	0	2	0	1	0	0	0	1
6	Austria	0	0	0	1	1	0	1	0	0	0	0	1	1
7	Belgium	0	0	0	1	1	0	1	0	1	0	0	0	0
8	Ireland	0	0	0	0	1	0	1	0	0	0	0	0	0
9	Luxembourg	0	0	0	1	0	0	0	0	1	0	0	0	0
10	Netherlands	0	0	0	1	1	0	1	0	0	0	0	0	0
11	Switzerland	0	0	0	1	1	0	1	0	1	0	0	0	0
13	Italy	0	0	0	1	1	0	1	0	1	0	0	0	0
14	Greece	0	0	0	0	0	0	1	0	1	0	0	0	0
15	Portugal	0	0	0	0	0	0	1	0	4	0	0	0	0
16	Spain	0	0	0	1	1	0	1	2	1	1	1	0	0
17	Turkey	0	0	0	0	0	0	2	0	0	0	0	1	0
19	Denmark	0	0	0	0	1	0	1	0	0	0	0	0	0
20	Finland	0	0	0	0	1	0	1	0	1	0	0	0	0
21	Norway	0	0	0	0	1	0	1	0	1	0	0	0	0
22	Sweden	0	0	0	0	2	0	1	0	1	0	0	0	0
23	Iceland	0	0	0	0	1	0	1	0	0	0	0	0	0
24	Bulgaria	0	0	0	1	1	0	1	0	0	0	0	0	0
25	Hungary	0	0	0	1	1	0	1	0	0	0	0	0	0
26	Poland	0	0	0	0	1	0	1	0	1	0	0	0	0
27	Czechoslovakia	0	0	0	1	0	0	0	0	1	0	0	0	0
28	Czech Republic	0	0	0	0	1	0	1	0	2	0	1	0	0
29	Slovakia	0	0	0	1	1	0	0	0	1	0	0	0	0
31	USSR	0	0	0	1	1	0	1	0	0	0	0	0	0
32	Russia	1	0	0	1	1	0	2	0	1	0	1	0	0
33	Ukraine	0	0	0	0	0	0	0	0	1	0	1	0	0
34	Baltic states	0	0	0	0	0	0	1	0	0	0	0	0	0
36	Japan	2	0	0	1	2	0	1	0	1	0	0	0	0

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Appendix table 5-54.

Patterns of international coauthorship in scientific and technical research: 1981-85 and 1991-95

(Percentages)

		Collaborating country (by country code)												
		1991-95												
Code	Country/region	39	40	41	42	44	45	46	48	49	50	52	54	56
37	China	1	1	4	1	3	0	0	0	1	0	0	0	0
38	Taiwan	1	1	3	1	1	0	1	0	0	0	0	0	1
39	South Korea		0	0	1	1	0	0	0	1	0	0	0	0
40	Singapore	0		2	2	10	1	0	0	1	0	0	0	0
41	Hong Kong	0	1		1	5	1	0	0	1	0	0	0	0
42	India	0	0	0		2	0	0	0	1	0	1	0	0
44	Australia	0	1	1	1		4	1	0	1	0	0	0	1
45	New Zealand	0	0	1	1	17		1	0	0	0	0	0	1
46	Israel	0	0	0	0	1	0		0	1	0	0	0	1
48	Argentina	0	0	0	0	1	0	1		8	3	2	0	1
49	Brazil	0	0	0	1	1	0	1	3		1	1	0	1
50	Chile	0	0	0	1	1	0	1	4	4		2	0	1
52	Mexico	0	0	0	1	1	0	1	1	3	2		0	0
54	Egypt	0	0	0	1	0	0	0	0	0	0	0		0
56	South Africa	0	0	0	1	0	5	1	4	1	1	1	0	

NOTES: Listed countries received at least 0.3 percent of all citations for all natural science and engineering fields combined. Hong Kong data were included with United Kingdom through 1986. Details may not add to totals because of rounding.

SOURCES: Institute for Scientific Information, Science Citation Index; CHI Research, Inc., Science Indicators database; and National Science Foundation, unpublished tabulations.

See figure 5-28.

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Science & Engineering Indicators – 1998

Appendix table 5-55.

Selected countries' citations to the international scientific and technical literature: 1995 articles citing 1991-93 publications

(Percentages)

Code	Country/region	Citations received (by country code)																																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
		All natural science and engineering fields																																
1	United States	67	3	6	3	4	0	1	2	1	1	1	0	1	0	0	1	0	0	1	0	0	4	0	0	0	0	0	0	1	0	0	0	0
2	Canada	42	25	7	3	4	0	1	2	1	2	1	0	1	1	0	1	0	0	1	0	0	4	0	0	0	0	0	0	2	0	0	0	0
3	United Kingdom	37	3	30	4	5	0	1	2	2	2	1	1	1	1	0	2	0	0	1	0	0	4	0	0	0	0	0	0	2	0	0	0	1
4	France	38	3	7	24	6	0	1	2	2	2	1	1	1	0	0	1	0	0	1	0	0	5	0	0	0	0	0	0	1	0	0	0	1
5	Germany	37	3	6	4	27	1	1	2	2	2	1	0	1	1	0	1	0	1	1	0	0	5	0	0	0	0	0	0	1	0	0	0	0
6	Austria	38	3	7	4	9	15	1	2	2	2	1	1	1	1	0	2	0	1	1	0	0	4	0	0	0	0	0	0	1	0	0	0	1
7	Belgium	37	3	8	6	6	0	17	3	2	2	1	1	1	1	0	2	0	0	1	0	0	5	0	0	0	0	0	0	1	0	0	0	1
8	Netherlands	38	3	8	4	6	0	1	21	2	2	1	0	1	1	0	2	0	0	1	0	0	4	0	0	0	0	0	0	1	0	0	0	0
9	Switzerland	42	3	7	4	8	1	1	2	16	3	1	0	1	1	0	1	0	0	1	0	0	5	0	0	0	0	0	0	1	0	0	0	1
10	Italy	37	3	8	4	6	1	1	2	2	21	1	1	1	1	0	2	0	0	1	0	0	5	0	0	0	0	0	0	1	0	0	0	0
11	Spain	33	3	7	5	5	0	1	2	2	3	22	1	1	1	0	1	0	1	1	0	0	5	0	0	0	0	0	1	1	0	0	1	1
12	Other W./S. Europe	34	3	9	4	6	1	1	2	1	3	2	16	1	1	1	2	0	1	1	0	0	5	1	0	0	0	0	1	1	0	0	0	1
13	Denmark	35	4	9	4	6	0	1	3	2	2	1	1	20	1	1	4	0	0	1	0	0	4	0	0	0	0	0	0	1	0	0	0	0
14	Finland	37	4	8	3	5	1	1	2	2	2	1	0	1	20	1	4	0	1	1	0	0	4	0	0	0	0	0	0	2	0	0	0	0
15	Norway	35	4	9	3	5	0	1	3	1	2	1	1	2	1	19	4	0	0	1	0	0	4	0	0	0	0	0	0	1	0	0	0	1
16	Sweden	36	3	7	3	5	0	1	2	1	2	1	0	2	1	1	23	0	0	1	0	0	4	0	0	0	0	0	0	1	0	0	0	0
17	Poland	29	3	6	5	8	1	1	2	2	3	1	1	1	1	0	2	21	1	1	1	0	6	1	0	0	0	0	1	1	0	0	1	0
18	Other E. Europe	32	3	6	5	8	1	1	2	2	3	2	1	1	1	0	2	1	18	1	1	0	6	1	0	0	0	0	1	1	0	0	1	1
19	Israel	45	3	6	4	6	0	1	2	2	2	1	0	1	0	0	1	0	0	18	0	0	4	0	0	0	0	0	0	1	0	0	0	1
20	Russia	35	3	6	5	9	0	1	2	2	3	1	1	1	1	0	1	1	1	1	17	1	7	1	0	0	0	0	1	1	0	0	0	0
21	Other former USSR	33	3	6	5	9	1	1	2	2	3	1	1	1	1	0	2	1	1	1	3	12	8	1	0	0	0	0	1	1	0	0	0	0
22	Japan	35	3	5	3	4	0	1	1	1	2	1	0	0	0	0	1	0	0	1	0	0	37	0	0	0	0	0	0	1	0	0	0	0
23	China	35	3	5	4	7	0	1	2	1	2	1	1	1	0	0	1	1	1	1	0	0	9	19	1	1	0	0	1	1	0	0	0	1
24	Taiwan	41	3	6	3	4	0	1	2	1	2	1	1	0	0	0	1	0	0	1	0	0	8	1	19	0	0	0	1	1	0	0	0	1
25	South Korea	44	3	5	3	4	0	1	2	1	2	1	1	0	0	0	1	0	1	1	0	0	12	1	1	12	0	0	1	1	0	0	1	0
26	Singapore	36	3	9	3	3	0	1	2	2	2	1	1	0	1	0	1	0	1	1	0	0	7	1	2	0	16	0	1	3	0	0	0	1
27	Hong Kong	38	4	10	4	5	0	1	2	1	2	1	1	1	1	0	1	0	0	1	0	0	6	2	1	0	0	11	2	3	0	0	1	1
28	India	31	3	6	4	5	0	1	1	1	2	1	1	0	0	0	1	1	1	1	0	0	6	1	1	0	0	0	29	1	0	0	1	1
29	Australia	37	4	9	3	4	0	1	2	1	2	1	0	1	0	0	2	0	0	1	0	0	4	0	0	0	0	0	0	23	1	0	0	1
30	New Zealand	36	4	11	3	4	0	1	2	2	3	1	1	1	1	0	2	0	0	1	0	0	4	0	0	0	0	0	0	5	16	0	0	1
31	Brazil	36	4	7	5	5	0	1	2	1	3	1	1	1	0	0	1	0	0	1	0	0	5	1	0	0	0	0	1	1	0	18	2	1
32	Other C. & S. America	38	4	7	4	5	0	1	2	1	3	3	1	1	0	0	1	0	1	1	0	0	4	0	0	0	0	0	1	2	0	1	17	1
33	All other countries	30	3	9	5	4	0	1	2	1	2	1	1	1	1	0	1	0	1	1	0	0	4	1	0	0	0	0	2	3	0	1	1	24

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Appendix table 5-55.

Selected countries' citations to the international scientific and technical literature: 1995 articles citing 1991-93 publications

(Percentages)

Code	Country/region	Citations received (by country code)																																
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
		Clinical medicine																																
1	United States	67	3	6	3	3	0	1	2	1	2	1	0	1	1	0	1	0	0	1	0	0	4	0	0	0	0	0	0	1	0	0	0	0
2	Canada	46	20	8	3	3	0	1	2	1	2	1	0	1	1	0	2	0	0	1	0	0	4	0	0	0	0	0	0	2	0	0	0	0
3	United Kingdom	37	3	31	3	4	1	1	2	1	2	1	1	1	1	0	2	0	0	1	0	0	4	0	0	0	0	0	0	2	0	0	0	1
4	France	42	3	9	18	4	1	1	2	2	3	1	0	1	1	0	2	0	0	1	0	0	5	0	0	0	0	0	0	2	0	0	0	1
5	Germany	42	3	8	4	20	1	1	2	2	3	1	0	1	1	0	2	0	0	1	0	0	5	0	0	0	0	0	0	1	0	0	0	0
6	Austria	41	3	9	4	8	11	1	3	3	3	1	1	1	1	0	2	0	0	1	0	0	4	0	0	0	0	0	0	2	0	0	0	1
7	Belgium	40	4	9	5	5	1	15	3	2	3	1	1	1	1	0	2	0	0	1	0	0	5	0	0	0	0	0	0	2	0	0	0	1
8	Netherlands	40	3	10	3	5	1	1	19	2	2	1	0	1	1	1	2	0	0	1	0	0	4	0	0	0	0	0	0	2	0	0	0	0
9	Switzerland	44	3	9	4	6	1	1	2	13	3	1	0	1	1	0	2	0	0	1	0	0	5	0	0	0	0	0	0	2	0	0	0	1
10	Italy	40	3	9	4	4	1	1	2	2	18	1	1	1	1	0	2	0	0	1	0	0	5	0	0	0	0	0	0	1	0	0	0	0
11	Spain	41	3	9	5	4	1	1	2	2	4	15	1	1	1	0	2	0	0	1	0	0	5	0	0	0	0	0	0	1	0	0	1	1
12	Other W./S. Europe	39	4	11	4	4	1	1	3	1	4	1	11	1	1	1	2	0	0	1	0	0	5	0	0	0	0	0	0	1	0	0	0	1
13	Denmark	36	3	10	3	4	0	1	3	2	2	1	0	19	1	1	4	0	0	1	0	0	4	0	0	0	0	0	0	2	0	0	0	1
14	Finland	39	3	9	3	4	1	1	2	1	2	0	1	1	19	1	3	0	0	1	0	0	4	0	0	0	0	0	0	2	0	0	0	0
15	Norway	37	4	9	3	4	1	1	3	2	2	1	1	2	1	18	5	0	0	1	0	0	4	0	0	0	0	0	0	2	0	0	0	1
16	Sweden	37	3	9	3	4	1	1	2	1	2	1	0	2	2	1	23	0	0	1	0	0	4	0	0	0	0	0	0	1	0	0	0	0
17	Poland	38	3	9	4	7	1	1	2	2	4	2	1	1	1	0	3	10	1	1	0	0	5	0	0	0	0	0	1	1	1	0	0	0
18	Other E. Europe	37	3	9	4	6	1	1	2	2	3	1	1	1	1	1	3	0	15	1	0	0	5	0	0	0	0	0	0	2	0	0	0	0
19	Israel	47	4	7	3	3	1	1	2	2	2	1	0	1	1	0	2	0	0	16	0	0	4	0	0	0	0	0	0	2	0	0	0	1
20	Russia	42	5	9	5	5	1	1	3	2	3	1	1	1	1	0	3	0	1	1	9	0	4	0	0	0	0	0	0	2	0	0	0	0
21	Other former USSR	39	3	11	5	8	0	0	2	2	3	0	1	1	2	1	4	0	0	1	1	7	4	0	0	0	0	0	0	1	0	0	0	1
22	Japan	39	3	7	3	4	0	1	1	1	2	1	0	1	1	0	1	0	0	1	0	0	31	0	0	0	0	0	0	1	0	0	0	0
23	China	40	3	8	3	4	0	1	2	1	3	1	1	1	1	1	2	0	0	1	0	0	10	11	1	0	0	1	1	1	0	0	0	1
24	Taiwan	41	3	8	3	4	0	1	2	1	3	1	1	1	1	1	2	0	0	1	0	0	9	1	13	0	0	1	1	2	0	0	0	1
25	South Korea	49	2	6	3	3	1	1	2	2	3	1	1	1	1	0	1	0	0	1	0	0	10	0	1	7	0	0	1	1	0	0	0	1
26	Singapore	40	3	11	4	3	0	1	1	1	3	2	1	0	1	0	1	0	0	1	0	0	8	1	2	0	9	1	1	3	1	0	0	2
27	Hong Kong	38	3	13	4	3	0	1	2	1	3	1	1	1	1	0	2	0	0	1	0	0	6	1	0	0	0	11	1	2	1	0	0	1
28	India	34	3	9	3	3	0	1	2	1	2	1	1	1	1	0	1	0	0	1	0	0	4	0	0	0	0	0	22	1	0	1	1	4
29	Australia	41	4	11	3	4	0	1	2	2	2	1	0	1	1	0	2	0	0	1	0	0	4	0	0	0	0	0	0	18	1	0	0	1
30	New Zealand	38	4	12	4	4	1	1	2	2	4	1	1	1	1	1	2	0	0	1	0	0	4	0	0	0	0	0	0	4	11	0	0	1
31	Brazil	42	4	10	4	3	0	1	2	1	3	1	1	1	1	0	1	0	0	1	0	0	5	0	0	0	0	0	1	2	0	15	2	2
32	Other C. & S. America	43	3	7	5	4	0	1	2	1	3	1	1	1	1	0	1	0	0	1	0	0	4	0	0	0	0	0	1	2	0	1	14	1
33	All other countries	35	3	12	4	3	1	1	2	2	2	1	1	1	1	1	2	0	0	1	0	0	3	0	1	0	0	0	1	2	0	1	1	19

Appendix table 5-55.

Selected countries' citations to the international scientific and technical literature: 1995 articles citing 1991-93 publications

(Percentages)

		Citations received (by country code)																																
Code	Country/region	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
		Biomedical research																																
1	United States	68	3	6	3	4	0	0	1	2	1	0	0	0	0	0	1	0	0	1	0	0	4	0	0	0	0	0	0	1	0	0	0	0
2	Canada	47	21	6	4	5	0	1	2	2	1	1	0	1	0	0	1	0	0	1	0	0	4	0	0	0	0	0	0	1	0	0	0	0
3	United Kingdom	42	3	27	4	6	0	1	2	2	1	1	0	1	0	0	1	0	0	1	0	0	5	0	0	0	0	0	0	1	0	0	0	0
4	France	42	3	7	22	5	0	1	2	2	2	1	0	1	0	0	1	0	0	1	0	0	5	0	0	0	0	0	0	1	0	0	0	0
5	Germany	43	3	7	4	24	1	1	2	2	1	1	0	1	0	0	1	0	0	1	0	0	5	0	0	0	0	0	0	1	0	0	0	0
6	Austria	43	4	6	4	9	14	1	2	2	2	1	1	1	1	0	2	0	0	1	0	0	4	0	0	0	0	0	0	2	0	0	0	0
7	Belgium	38	3	7	6	6	0	17	4	2	1	1	1	1	0	0	1	0	1	1	0	0	5	0	0	0	0	0	0	1	0	0	0	0
8	Netherlands	40	3	7	5	6	0	1	21	2	1	1	0	1	1	0	2	0	0	1	0	0	4	0	0	0	0	0	0	1	0	0	0	0
9	Switzerland	47	2	7	4	7	0	1	2	16	2	0	0	1	0	0	1	0	0	1	0	0	5	0	0	0	0	0	0	1	0	0	0	0
10	Italy	42	3	7	4	5	1	1	2	2	19	1	0	1	1	0	2	0	0	1	0	0	5	0	0	0	0	0	0	1	0	0	0	0
11	Spain	38	4	8	5	5	1	1	2	2	2	20	0	1	1	0	1	0	0	1	0	0	4	0	0	0	0	0	0	1	0	0	1	0
12	Other W./S. Europe	39	3	9	4	7	1	1	3	1	3	1	13	1	1	1	2	0	1	1	0	0	5	0	0	0	0	0	1	1	0	0	0	1
13	Denmark	39	4	7	4	6	0	1	3	2	1	1	0	20	1	1	3	0	0	1	0	0	4	0	0	0	0	0	0	1	0	0	0	0
14	Finland	41	3	7	4	5	1	1	3	2	1	1	0	1	19	0	3	0	0	1	0	0	5	0	0	0	0	0	0	1	0	0	0	0
15	Norway	40	3	8	4	6	1	1	2	1	2	1	0	1	1	18	3	0	0	1	0	0	4	0	0	0	0	0	0	1	0	0	0	0
16	Sweden	42	3	6	4	5	0	1	2	2	1	1	0	1	1	1	21	0	0	1	0	0	4	0	0	0	0	0	0	2	0	0	0	0
17	Poland	40	3	6	5	7	1	1	1	2	2	1	1	1	1	0	2	14	1	1	1	0	6	0	0	0	0	0	0	1	0	0	0	0
18	Other E. Europe	41	4	8	5	6	1	1	2	2	2	1	1	1	1	0	2	0	12	1	0	0	6	0	0	0	0	0	0	1	0	0	0	0
19	Israel	49	3	7	4	6	0	0	2	2	1	1	0	0	0	0	1	0	0	16	0	0	5	0	0	0	0	0	0	1	0	0	0	0
20	Russia	43	3	7	5	7	0	1	2	2	1	1	0	1	1	0	2	0	1	1	13	0	5	0	0	0	0	0	1	1	0	0	0	0
21	Other former USSR	42	3	9	4	7	1	2	3	1	2	1	0	1	0	0	2	1	0	1	1	8	6	0	0	0	0	0	0	2	0	0	1	0
22	Japan	41	3	6	3	4	0	1	1	1	1	1	0	0	0	0	1	0	0	1	0	0	31	0	0	0	0	0	0	1	0	0	0	0
23	China	39	3	7	4	5	0	1	2	1	3	1	1	0	1	0	1	0	0	1	0	0	8	15	0	0	0	0	1	2	0	0	0	1
24	Taiwan	45	3	6	4	4	0	1	1	1	1	1	1	0	0	0	1	0	0	1	0	0	8	1	18	0	0	0	1	1	0	0	0	0
25	South Korea	51	4	7	3	4	0	1	2	1	1	0	0	0	0	0	2	0	0	1	0	0	11	0	0	8	0	0	1	1	0	0	0	0
26	Singapore	42	4	12	3	4	1	2	1	2	1	1	0	1	0	0	1	0	1	1	0	0	6	0	1	0	13	0	1	2	0	0	0	1
27	Hong Kong	44	4	8	4	5	0	1	2	0	1	1	0	0	2	1	1	0	1	0	0	0	6	1	1	0	1	12	0	2	0	0	1	0
28	India	41	3	7	3	5	0	1	1	1	2	1	1	0	1	0	2	0	0	1	0	0	5	0	0	0	0	0	19	1	0	0	1	1
29	Australia	42	4	9	4	5	0	1	2	2	1	1	0	1	0	0	2	0	0	1	0	0	5	0	0	0	0	0	0	19	0	0	0	1
30	New Zealand	39	4	10	4	4	0	0	2	2	1	0	0	1	1	0	1	0	0	1	0	0	5	0	0	0	0	0	0	4	17	0	1	0
31	Brazil	39	4	9	5	4	0	1	2	1	2	1	1	1	0	0	2	0	0	1	0	0	5	0	0	0	0	0	0	2	0	17	2	1
32	Other C. & S. America	40	4	8	5	5	0	1	2	1	2	2	0	1	0	0	1	0	0	1	0	0	5	0	0	0	0	0	0	2	0	1	16	1
33	All other countries	35	3	10	4	3	1	1	2	1	2	1	0	0	1	0	2	0	0	1	0	0	5	0	0	0	0	0	1	3	0	0	1	21

Appendix table 5-55.

Selected countries' citations to the international scientific and technical literature: 1995 articles citing 1991-93 publications

(Percentages)

Code	Country/region	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
		Citations received (by country code)																																
	Biology																																	
1	United States	68	5	5	2	3	0	0	2	1	1	1	0	0	0	0	1	0	0	1	0	0	3	0	0	0	0	0	0	2	1	0	1	1
2	Canada	34	38	6	2	3	0	0	2	0	1	1	0	1	0	1	2	0	0	0	0	0	2	0	0	0	0	0	0	3	1	0	0	1
3	United Kingdom	28	5	36	3	4	0	1	3	1	1	1	1	1	1	1	2	0	0	1	0	0	3	0	0	0	0	0	0	4	1	0	1	2
4	France	28	5	8	29	5	0	1	3	1	1	2	1	1	1	1	1	0	0	1	0	0	4	0	0	0	0	0	0	3	1	0	1	2
5	Germany	28	4	8	3	32	1	1	3	2	1	1	0	1	1	0	2	0	1	1	0	0	4	0	0	0	0	0	0	3	1	0	1	1
6	Austria	29	6	7	3	10	17	1	3	1	2	2	1	2	1	0	4	0	0	0	0	0	4	0	0	0	0	0	0	2	0	0	1	1
7	Belgium	30	4	8	6	6	1	19	4	2	1	2	1	1	1	1	3	0	0	1	0	0	3	0	0	0	0	0	1	2	1	0	0	1
8	Netherlands	26	6	8	4	5	0	1	31	1	1	1	0	1	0	1	3	0	0	1	0	0	3	0	0	0	0	0	0	3	1	0	1	1
9	Switzerland	37	4	8	4	7	0	0	4	19	1	1	0	1	1	0	2	0	0	1	0	0	4	0	0	0	0	0	1	1	0	0	1	1
10	Italy	29	4	7	5	6	0	1	2	2	24	3	1	1	0	0	1	0	1	2	0	0	4	0	0	0	0	0	1	4	0	0	1	1
11	Spain	27	5	7	4	4	0	1	2	1	2	28	2	1	1	1	2	0	0	1	0	0	3	0	0	0	0	0	1	3	1	0	1	1
12	Other W./S. Europe	28	5	10	4	5	1	1	4	1	2	2	19	1	1	1	2	0	1	1	0	0	3	0	0	0	0	0	1	4	1	0	1	2
13	Denmark	24	7	11	4	5	0	1	4	1	2	1	0	25	1	1	4	0	0	1	0	0	3	0	0	0	0	0	0	3	1	0	0	0
14	Finland	26	6	10	3	4	0	1	3	1	1	1	0	1	26	2	6	0	1	1	0	0	2	0	0	0	0	0	0	2	0	0	0	1
15	Norway	23	8	12	3	3	0	1	2	0	1	1	1	2	2	27	6	0	0	0	0	0	3	0	0	0	0	0	0	1	1	0	1	1
16	Sweden	28	6	8	2	4	0	1	4	1	1	1	0	1	1	2	30	0	1	1	0	0	2	0	0	0	0	0	1	3	1	0	0	1
17	Poland	26	5	8	4	7	1	1	2	1	2	1	2	2	2	0	4	19	1	1	0	0	6	0	0	0	0	0	1	3	1	0	1	1
18	Other E. Europe	24	3	9	5	7	0	1	4	1	2	2	1	0	0	1	2	1	19	1	1	0	7	0	0	0	0	0	1	2	1	0	1	1
19	Israel	35	4	6	3	4	0	1	2	0	1	2	1	1	0	0	1	0	0	26	0	0	5	0	0	0	0	0	0	3	1	0	0	1
20	Russia	33	5	10	4	6	0	0	1	1	1	2	1	0	1	1	3	1	1	0	13	1	7	1	1	0	0	0	0	3	0	0	1	1
21	Other former USSR	41	6	8	5	10	1	1	2	0	2	1	1	0	2	2	4	0	1	0	1	7	2	1	0	0	0	0	1	1	0	1	1	1
22	Japan	29	3	5	3	5	0	1	2	1	1	1	0	0	0	0	1	0	0	1	0	0	43	0	0	0	0	0	0	2	0	0	0	1
23	China	30	8	6	3	5	0	1	2	1	3	1	2	1	0	0	1	0	1	0	0	0	11	13	1	1	0	1	1	2	2	0	1	2
24	Taiwan	34	5	3	2	3	0	0	1	1	2	0	0	0	1	0	0	0	1	1	0	0	8	1	29	0	0	0	1	1	0	0	2	1
25	South Korea	44	4	7	2	6	0	1	1	1	2	0	2	0	0	1	0	0	0	0	0	0	13	1	1	6	0	0	1	1	0	0	0	0
26	Singapore	29	7	7	2	2	0	1	2	1	0	2	0	0	0	1	2	1	1	0	0	0	8	1	1	0	25	1	3	2	2	0	1	3
27	Hong Kong	35	3	7	4	1	2	1	3	0	2	2	1	1	0	0	0	1	0	1	0	0	2	3	4	1	2	8	1	13	1	0	1	3
28	India	27	4	6	3	4	0	1	1	1	3	2	1	0	0	0	1	0	1	1	0	0	3	1	0	0	0	0	29	5	1	0	1	3
29	Australia	27	5	8	2	3	0	0	2	1	0	1	0	0	0	0	1	0	0	1	0	0	2	0	0	0	0	0	0	40	2	0	1	2
30	New Zealand	28	5	9	2	3	0	1	3	1	1	0	1	1	1	0	1	0	0	1	0	0	2	0	0	0	0	0	1	9	30	0	1	1
31	Brazil	33	5	6	4	4	0	1	2	2	1	1	0	0	0	0	1	0	2	1	0	0	4	0	0	0	0	0	2	3	1	23	2	2
32	Other C. & S. America	37	5	6	2	3	0	0	2	1	2	2	1	1	0	0	1	0	0	1	0	0	3	0	0	0	0	0	1	4	1	1	21	3
33	All other countries	25	4	8	4	4	1	1	2	1	1	2	1	1	0	0	1	0	0	1	0	0	2	0	0	0	0	0	2	6	1	0	2	31

Appendix table 5-55.

Selected countries' citations to the international scientific and technical literature: 1995 articles citing 1991-93 publications

(Percentages)

Code	Country/region	Citations received (by country code)																																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
															Chemistry																					
1	United States	62	3	5	3	6	0	0	1	1	2	1	1	0	0	0	1	0	1	1	0	0	6	0	0	0	0	0	1	1	0	0	0	0
2	Canada	32	28	5	4	6	0	1	2	1	3	2	1	0	0	0	1	1	1	1	0	0	6	0	0	0	0	0	1	1	0	0	0	1
3	United Kingdom	29	3	30	4	7	0	1	2	1	2	2	1	0	0	0	1	0	1	0	0	0	7	1	0	0	0	0	1	1	0	0	1	1
4	France	28	3	6	31	6	0	1	2	1	2	2	1	0	0	0	1	1	1	1	0	0	7	1	0	0	0	0	1	1	0	0	0	1
5	Germany	27	3	5	4	38	1	1	2	2	2	1	1	0	0	0	1	1	1	1	0	0	6	1	0	0	0	0	1	1	0	0	0	0
6	Austria	26	3	5	4	11	24	1	1	2	2	2	1	1	0	0	1	1	2	0	0	1	7	0	0	0	0	0	1	1	0	0	0	1
7	Belgium	28	4	6	6	7	0	21	3	2	3	2	1	1	0	1	2	2	1	0	1	0	6	0	1	0	0	0	1	1	0	0	1	1
8	Netherlands	31	3	6	5	6	1	1	25	2	3	2	0	1	0	0	2	1	1	1	0	0	7	1	0	0	0	0	1	1	0	0	0	0
9	Switzerland	33	3	7	4	9	1	1	2	22	4	1	1	0	0	0	1	1	1	0	0	0	6	1	0	0	0	0	1	1	0	0	0	1
10	Italy	27	3	6	5	6	0	1	2	2	29	2	1	0	0	0	1	0	1	1	0	0	7	1	0	0	0	0	1	1	0	0	0	0
11	Spain	24	3	5	5	6	0	1	2	1	3	29	1	0	0	0	1	1	1	0	0	0	6	1	1	0	0	0	1	1	0	0	1	1
12	Other W./S. Europe	25	3	7	4	6	0	1	2	1	3	3	25	1	0	0	1	1	2	0	0	0	7	1	1	0	0	0	1	1	0	0	1	1
13	Denmark	30	4	6	5	7	0	1	1	2	2	1	1	23	0	0	4	0	2	1	1	0	7	0	0	0	0	0	1	1	0	0	0	0
14	Finland	32	3	5	4	7	0	0	2	1	2	2	1	1	22	0	3	1	2	0	0	0	5	0	1	0	0	0	0	1	0	0	0	1
15	Norway	30	4	4	4	6	0	2	2	2	2	1	1	1	0	19	5	1	1	0	0	0	7	0	0	0	0	0	1	1	0	0	0	0
16	Sweden	28	3	6	4	6	0	1	3	2	2	1	1	1	0	1	26	1	1	1	0	0	7	1	0	0	0	0	1	2	0	0	0	0
17	Poland	23	3	5	5	6	1	1	2	2	3	2	1	0	1	0	1	30	1	1	1	0	5	1	1	0	0	0	2	1	0	0	0	1
18	Other E. Europe	25	3	5	5	7	1	1	2	2	3	2	2	0	1	0	2	1	22	0	1	0	8	1	0	0	0	0	2	1	0	0	1	1
19	Israel	38	4	5	5	9	0	1	2	1	2	1	1	1	0	0	1	0	0	19	0	0	6	0	0	0	0	0	1	1	0	0	0	0
20	Russia	27	3	5	5	7	0	1	2	1	3	1	1	1	0	0	1	1	1	1	25	1	8	1	0	0	0	0	1	1	0	0	0	1
21	Other former USSR	20	2	5	4	8	0	1	2	2	3	2	2	1	1	0	2	2	2	0	5	21	10	1	1	1	0	0	1	1	0	0	0	1
22	Japan	27	2	4	3	5	0	0	1	1	1	1	0	0	0	0	1	0	1	0	0	0	47	1	0	0	0	0	1	1	0	0	0	0
23	China	28	2	5	4	7	0	0	1	1	2	2	1	0	0	0	1	1	1	1	0	0	10	24	1	1	0	0	2	1	0	0	0	1
24	Taiwan	34	3	4	3	5	0	1	2	1	2	1	1	0	0	0	1	1	0	0	0	0	8	1	27	1	0	0	2	1	0	0	1	1
25	South Korea	37	4	5	3	4	1	1	1	1	3	1	0	0	0	0	0	0	1	0	0	0	12	1	1	19	0	0	1	1	0	0	1	0
26	Singapore	32	3	8	4	4	0	1	3	3	3	3	0	0	1	0	1	0	1	0	0	0	7	2	2	1	16	0	1	2	0	1	1	1
27	Hong Kong	33	4	9	3	8	0	0	1	2	3	1	1	0	0	0	1	0	1	1	0	0	8	1	1	0	0	10	6	2	0	1	1	1
28	India	22	2	5	3	4	0	1	1	1	3	2	1	0	0	0	1	1	1	1	0	0	7	1	1	1	0	0	40	1	0	0	1	1
29	Australia	29	4	7	4	6	0	0	2	2	2	2	1	1	0	0	1	0	1	0	0	0	5	1	0	0	0	0	2	26	0	0	0	1
30	New Zealand	35	3	9	2	8	0	1	1	1	2	2	1	0	0	0	3	0	1	1	0	0	5	1	0	0	0	0	1	5	16	0	0	0
31	Brazil	28	5	6	5	6	0	1	2	1	3	2	2	0	0	0	1	0	1	0	0	0	6	1	0	0	0	0	1	1	0	23	1	1
32	Other C. & S. America	26	3	5	5	7	0	1	1	2	3	4	2	0	0	0	1	1	1	1	0	0	6	1	1	0	0	0	2	1	0	0	24	1
33	All other countries	19	3	5	7	6	0	1	1	1	2	2	2	0	0	0	1	1	1	0	0	0	6	1	1	0	0	0	3	1	0	0	1	33

Appendix table 5-55.

Selected countries' citations to the international scientific and technical literature: 1995 articles citing 1991-93 publications

(Percentages)

Code	Country/region	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
		Citations received (by country code)																																
	Physics																																	
1	United States	63	2	4	4	7	0	0	1	2	2	1	1	1	0	0	1	0	0	1	1	0	5	0	0	0	0	0	1	1	0	0	0	0
2	Canada	38	25	5	5	7	0	0	1	2	2	1	1	1	0	0	1	1	1	1	1	0	5	1	0	0	0	0	1	1	0	0	0	0
3	United Kingdom	34	3	28	5	7	1	1	2	2	3	1	1	1	0	0	1	1	0	1	1	0	5	1	0	0	0	0	1	1	0	0	0	0
4	France	31	2	5	29	9	0	1	2	2	3	1	1	1	0	0	1	1	1	1	1	0	6	1	0	0	0	0	1	1	0	0	0	0
5	Germany	32	2	4	5	33	1	0	2	2	2	1	1	1	0	0	1	1	1	1	1	0	5	1	0	0	0	0	1	1	0	0	0	0
6	Austria	32	2	5	6	12	19	1	1	2	2	1	1	1	0	0	1	1	2	1	1	0	5	1	0	0	0	0	1	1	0	0	0	1
7	Belgium	32	2	5	7	8	0	20	3	2	2	1	1	0	0	0	2	1	1	2	1	0	5	0	0	0	0	0	1	0	0	0	0	0
8	Netherlands	35	2	6	5	9	1	1	23	2	2	1	1	1	0	0	1	1	0	1	1	0	5	0	0	0	0	0	1	1	0	0	0	0
9	Switzerland	37	2	5	5	11	0	1	2	18	5	1	1	1	0	0	1	1	1	1	1	0	4	0	0	0	0	0	0	0	0	0	0	0
10	Italy	31	2	6	6	9	1	1	2	3	24	1	1	1	0	0	1	1	1	1	1	0	5	1	0	0	0	0	1	1	0	0	0	0
11	Spain	30	3	5	7	9	0	1	2	2	4	21	1	1	0	0	1	1	1	1	1	0	4	1	0	0	0	0	1	1	0	1	1	0
12	Other W./S. Europe	33	3	6	5	10	1	0	2	2	3	1	17	1	0	0	1	1	1	1	1	0	6	1	0	0	0	0	1	1	0	1	1	0
13	Denmark	36	3	7	5	10	0	0	2	2	3	2	1	15	0	1	3	1	1	1	1	0	4	0	0	0	0	0	1	1	0	0	0	0
14	Finland	30	2	6	6	11	0	1	1	3	2	1	0	2	19	0	2	1	1	1	1	0	5	1	0	0	0	0	1	2	0	0	1	0
15	Norway	31	2	7	6	10	0	1	1	2	3	1	1	3	1	17	3	1	1	1	1	0	4	1	0	0	0	0	1	1	0	1	0	0
16	Sweden	32	2	6	5	9	1	1	2	2	2	1	1	2	1	0	19	1	1	1	1	0	6	0	0	0	0	0	0	1	0	0	1	0
17	Poland	26	2	5	7	11	1	1	3	2	3	1	1	1	0	0	1	21	1	1	1	0	6	1	0	0	0	0	1	1	0	1	1	0
18	Other E. Europe	31	3	5	6	12	1	1	1	2	3	1	1	0	1	0	1	1	17	1	1	0	5	1	0	0	0	0	1	1	0	0	1	0
19	Israel	41	2	5	5	9	0	0	2	2	2	1	1	1	0	0	1	1	1	18	1	0	3	0	0	0	0	0	1	1	0	0	0	0
20	Russia	33	2	5	6	11	0	1	2	2	3	1	1	1	1	0	1	1	1	1	16	1	7	1	0	0	0	0	1	0	0	0	0	0
21	Other former USSR	32	2	5	5	11	1	1	2	2	3	1	1	1	1	0	1	1	1	1	3	12	9	1	0	0	0	0	1	1	0	0	0	0
22	Japan	30	2	3	4	6	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	43	1	0	0	0	0	1	1	0	0	0	0
23	China	36	2	4	4	7	0	0	2	2	2	1	1	1	0	0	1	1	1	1	1	0	9	18	1	0	0	0	1	1	0	1	1	0
24	Taiwan	46	2	4	3	6	0	0	1	1	2	1	0	0	0	0	1	1	1	1	0	0	10	1	14	0	0	0	1	1	0	0	0	0
25	South Korea	46	2	4	3	6	0	0	2	2	2	1	1	1	0	0	1	1	1	1	1	0	12	1	1	11	0	0	1	1	0	0	0	0
26	Singapore	28	1	6	4	4	0	2	1	1	2	0	1	0	0	0	1	1	1	1	0	0	8	1	2	0	26	0	2	3	1	0	0	1
27	Hong Kong	44	3	6	3	5	1	1	2	1	1	1	1	0	0	1	0	0	1	3	1	0	7	4	2	0	1	10	1	1	0	0	0	0
28	India	33	2	4	5	7	0	1	1	2	2	1	1	1	0	0	1	1	1	1	0	0	6	2	1	1	0	0	25	1	0	1	1	0
29	Australia	33	3	7	4	8	0	1	2	2	2	1	1	1	0	0	1	1	1	1	1	0	6	1	0	0	0	0	1	23	0	0	0	0
30	New Zealand	27	3	9	8	9	1	0	1	2	2	1	0	0	1	0	1	0	1	0	0	0	8	1	0	0	0	0	1	5	16	0	0	1
31	Brazil	31	3	5	7	8	0	1	1	2	3	1	2	1	0	0	1	1	1	1	1	0	4	1	0	1	0	0	1	1	0	20	2	1
32	Other C. & S. America	33	2	5	5	8	1	1	2	2	3	4	1	1	0	0	0	1	1	1	1	0	3	1	0	0	0	0	1	1	0	2	17	0
33	All other countries	25	2	7	6	8	0	1	2	1	3	1	1	0	1	0	0	1	1	1	0	0	6	1	0	0	0	0	3	2	0	1	1	22

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Appendix table 5-55.

Selected countries' citations to the international scientific and technical literature: 1995 articles citing 1991-93 publications

(Percentages)

Code	Country/region	Citations received (by country code)																																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
	Earth and space sciences																																	
1	United States	70	4	6	3	4	0	0	1	1	1	1	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	1	0
2	Canada	38	34	6	3	4	0	0	1	1	1	1	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	3	0	0	1	1
3	United Kingdom	41	4	28	4	5	0	0	2	1	2	1	1	1	0	1	1	0	0	0	0	0	2	0	0	0	0	0	1	3	0	0	1	1
4	France	39	5	6	25	5	0	1	2	1	3	1	1	1	0	0	1	0	0	1	1	0	2	0	0	0	0	0	0	2	0	0	1	1
5	Germany	43	4	7	5	22	0	0	2	1	2	1	1	1	0	1	1	0	0	0	0	0	2	0	0	0	0	0	1	2	0	0	1	1
6	Austria	39	7	4	5	11	15	1	1	4	2	1	1	0	1	1	1	0	2	0	0	0	1	0	0	0	1	0	1	2	0	0	0	1
7	Belgium	34	3	7	6	9	0	14	6	1	3	1	1	2	0	1	2	1	0	0	1	0	3	0	0	0	0	0	0	2	1	0	0	1
8	Netherlands	38	4	8	4	7	0	1	19	2	2	1	1	1	0	1	2	0	0	0	0	0	2	0	0	0	0	0	0	3	0	0	0	0
9	Switzerland	40	5	7	5	7	1	0	2	17	2	1	1	1	0	1	2	0	0	0	0	0	2	1	0	0	0	0	0	2	0	0	1	1
10	Italy	40	4	8	4	6	0	0	2	1	22	1	1	1	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	1	0
11	Spain	34	3	9	6	5	0	1	2	2	4	22	1	0	0	0	1	0	1	1	0	0	2	0	0	0	0	0	1	2	0	0	2	1
12	Other W./S. Europe	29	5	11	6	4	0	0	2	1	3	2	23	1	0	1	1	0	1	0	1	0	3	0	0	0	0	0	1	2	0	0	0	1
13	Denmark	35	7	8	4	5	0	1	3	1	3	1	1	20	0	2	4	0	0	0	1	0	1	0	0	0	0	0	0	2	0	0	1	1
14	Finland	32	9	7	1	6	0	1	2	1	2	0	1	1	22	1	6	0	0	0	1	0	2	0	0	0	0	0	0	2	0	0	0	0
15	Norway	37	7	8	3	5	0	0	3	1	2	1	1	2	0	22	3	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0
16	Sweden	35	5	6	4	7	0	0	3	1	1	1	1	2	1	2	24	0	0	1	0	0	3	1	0	0	0	0	0	1	0	0	1	0
17	Poland	41	7	7	6	7	1	1	1	2	3	1	1	0	1	0	2	10	1	1	0	0	2	0	0	0	0	0	0	2	0	0	1	0
18	Other E. Europe	29	4	8	6	10	1	1	1	4	3	1	1	2	1	1	1	1	18	1	0	0	1	0	0	0	0	0	0	2	0	0	0	1
19	Israel	50	2	8	3	4	0	0	2	1	2	1	0	1	0	0	1	0	0	17	1	0	2	0	0	0	0	0	0	2	0	0	1	1
20	Russia	45	4	7	5	7	0	0	1	1	3	1	1	1	1	1	1	0	0	1	13	0	2	0	0	0	0	0	0	3	0	0	1	0
21	Other former USSR	43	3	6	5	6	0	1	1	1	4	2	1	1	1	1	2	1	1	0	2	7	2	0	1	0	0	0	1	3	1	0	1	1
22	Japan	41	4	7	4	4	0	0	2	1	2	1	0	0	0	0	1	0	0	0	0	0	26	1	0	0	0	0	1	2	0	0	1	1
23	China	37	4	6	8	7	0	1	1	1	2	1	1	2	1	0	0	0	1	1	0	0	5	16	0	0	0	0	1	2	0	0	0	0
24	Taiwan	51	4	5	3	3	0	0	3	1	1	1	1	1	1	0	1	0	1	1	0	0	4	1	12	0	0	0	1	2	0	1	0	1
25	South Korea	54	4	7	4	6	0	0	1	0	5	1	1	0	0	0	1	0	0	0	0	0	4	0	0	4	0	0	0	1	0	0	3	0
26	Singapore	43	10	0	5	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	10	0	0	10	0	0	5	5
27	Hong Kong	28	5	11	2	5	0	0	6	2	2	3	2	0	0	0	0	0	0	0	0	0	5	2	0	2	0	12	0	12	2	0	2	2
28	India	34	3	8	3	5	0	1	1	1	3	1	1	0	0	0	1	1	0	0	0	0	3	0	0	0	0	0	28	3	0	1	0	1
29	Australia	38	6	8	3	4	0	0	2	1	1	0	0	0	0	0	0	0	0	1	0	0	2	1	0	0	0	0	0	28	1	0	1	1
30	New Zealand	39	6	8	3	2	1	0	2	1	1	1	1	0	0	1	1	0	0	0	1	0	3	0	0	0	0	0	1	6	23	1	0	0
31	Brazil	42	6	8	6	3	0	0	2	2	4	1	0	1	0	0	1	0	0	0	0	0	2	1	0	0	0	0	1	3	0	14	1	1
32	Other C. & S. America	44	5	7	4	5	0	0	1	1	4	2	1	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	1	3	0	1	15	1
33	All other countries	33	5	8	6	5	0	0	1	1	1	1	1	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	1	4	0	1	1	24

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Appendix table 5-55.

Selected countries' citations to the international scientific and technical literature: 1995 articles citing 1991-93 publications

(Percentages)

Code	Country/region	Citations received (by country code) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
	Engineering and technology																																	
1	United States	71	3	4	3	3	0	0	1	1	1	1	0	0	0	0	1	0	0	1	0	0	5	1	1	0	0	0	1	1	0	0	0	0
2	Canada	32	37	4	3	3	0	0	2	1	2	1	1	0	1	0	1	1	0	1	0	0	5	1	1	0	0	0	1	1	0	0	0	1
3	United Kingdom	29	4	39	3	4	0	0	2	1	2	1	1	0	0	0	1	1	0	0	0	0	5	1	0	0	0	0	1	1	0	0	0	1
4	France	27	2	5	34	6	0	0	3	1	2	1	1	0	0	0	1	1	1	0	0	0	7	1	0	0	0	0	1	1	0	1	1	1
5	Germany	26	2	5	4	41	1	1	2	1	2	1	1	0	0	0	1	1	1	0	0	0	7	1	0	0	0	0	1	1	0	0	0	0
6	Austria	28	2	5	8	10	23	0	1	3	2	0	1	0	0	0	1	1	2	0	0	0	8	1	0	1	0	0	0	0	0	0	0	0
7	Belgium	32	2	6	7	5	0	25	2	1	3	2	1	0	1	0	1	1	1	3	0	0	4	1	1	0	0	0	0	1	0	1	0	1
8	Netherlands	26	4	4	5	7	0	1	31	2	3	1	1	0	1	0	1	1	1	0	0	0	6	1	1	1	0	0	1	1	0	0	0	0
9	Switzerland	25	6	7	4	7	1	0	3	28	2	1	1	0	0	0	1	1	1	1	0	0	9	0	0	0	0	0	1	1	0	0	0	0
10	Italy	28	4	6	4	5	1	1	2	1	31	1	1	0	0	0	1	1	1	1	0	0	6	1	1	1	0	0	1	1	0	0	0	0
11	Spain	25	4	8	6	7	0	1	2	1	2	27	1	0	0	0	2	0	1	0	0	0	6	2	1	0	0	0	1	1	0	0	1	1
12	Other W./S. Europe	30	4	6	3	4	1	1	3	1	3	1	24	1	0	0	1	1	1	0	0	0	6	2	1	1	0	0	2	2	0	1	0	1
13	Denmark	29	3	6	4	6	1	1	2	1	1	1	1	29	1	2	1	0	0	1	1	0	3	2	1	0	0	1	1	1	1	0	0	2
14	Finland	25	5	5	4	4	1	0	2	1	2	1	1	1	32	0	3	1	1	1	1	0	4	1	1	1	0	0	0	2	1	0	0	0
15	Norway	39	7	5	5	5	0	1	2	2	2	1	1	1	0	19	3	1	1	1	0	1	2	1	0	1	0	0	1	1	0	1	0	1
16	Sweden	32	5	7	3	4	0	1	2	1	1	1	1	1	1	0	28	1	1	1	0	0	5	1	1	0	0	0	1	1	0	0	0	0
17	Poland	20	4	5	4	8	0	1	4	4	3	1	1	0	0	0	1	29	0	0	0	0	6	1	0	1	0	0	2	1	0	1	0	0
18	Other E. Europe	26	2	5	4	8	1	0	3	1	2	2	2	0	1	0	1	1	23	1	0	0	9	2	1	1	0	0	2	1	0	0	1	0
19	Israel	45	3	3	4	5	1	0	1	1	1	1	1	0	0	0	1	0	1	24	1	0	3	1	1	1	0	0	1	1	0	0	0	1
20	Russia	29	3	4	5	8	1	0	2	1	2	1	1	1	0	1	1	1	2	0	21	1	10	1	1	0	0	0	1	1	0	0	0	0
21	Other former USSR	29	4	4	6	8	0	0	1	2	2	1	2	0	2	0	1	3	1	0	2	12	10	2	0	0	0	0	2	1	0	0	0	0
22	Japan	24	2	3	2	4	0	0	1	1	1	1	1	0	0	0	1	0	0	0	0	0	53	1	1	0	0	0	1	1	0	0	0	0
23	China	31	4	5	3	6	1	0	1	0	1	1	2	0	0	0	1	1	0	0	0	0	9	25	2	1	0	1	2	1	0	0	0	1
24	Taiwan	41	3	4	2	3	0	0	1	0	1	1	1	0	0	0	1	0	1	1	0	0	7	1	25	1	0	0	2	1	0	0	0	0
25	South Korea	40	3	3	3	3	0	1	1	1	1	1	1	0	1	0	1	0	1	1	0	0	16	1	3	18	0	0	1	1	0	0	0	0
26	Singapore	38	3	8	4	2	0	1	2	1	2	1	1	0	1	0	1	0	0	1	0	0	4	2	2	0	16	0	3	6	0	1	1	1
27	Hong Kong	34	7	7	4	2	0	0	2	0	1	0	1	0	0	0	1	0	1	0	0	0	6	5	2	1	0	19	1	2	0	0	0	0
28	India	29	4	6	3	3	0	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	9	2	1	1	0	0	32	1	0	0	0	1
29	Australia	31	5	6	3	4	0	1	2	1	2	0	1	1	0	0	1	1	0	1	0	0	5	1	1	0	0	0	2	28	0	0	0	0
30	New Zealand	30	9	11	3	2	0	0	2	1	3	1	1	2	1	0	1	1	1	2	0	0	3	0	0	0	1	2	0	3	23	0	0	1
31	Brazil	31	3	6	7	4	0	0	2	2	3	1	2	0	0	1	0	1	0	1	0	0	6	0	1	0	0	0	2	2	0	24	1	0
32	Other C. & S. America	24	3	5	3	2	0	1	2	2	2	5	1	1	1	0	4	1	1	0	0	0	5	1	1	0	0	0	2	3	0	1	29	1
33	All other countries	23	5	6	6	4	0	1	1	0	2	1	2	0	0	0	1	0	1	1	0	0	6	1	1	0	0	0	3	1	0	1	0	30

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Appendix table 5-55.

Selected countries' citations to the international scientific and technical literature: 1995 articles citing 1991-93 publications

(Percentages)

Code	Country/region	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
		Citations received (by country code)																																
	Mathematics																																	
1	United States	69	3	4	4	3	0	0	1	1	1	1	1	1	0	0	1	0	1	1	0	0	3	1	0	0	0	0	0	1	0	1	0	0
2	Canada	36	33	6	3	4	1	0	1	1	2	1	1	1	0	1	0	0	0	1	0	0	2	2	0	0	0	0	0	2	1	0	0	0
3	United Kingdom	35	3	40	3	4	0	0	1	2	1	0	1	1	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	2	0	1	0	1
4	France	31	2	3	40	4	0	0	2	1	2	1	1	1	0	0	1	1	1	1	0	0	3	1	0	0	0	0	0	1	0	1	1	1
5	Germany	34	3	4	3	34	1	2	1	2	1	1	1	0	0	1	1	0	1	1	0	0	3	1	0	0	0	0	0	1	0	0	0	1
6	Austria	29	3	6	4	7	36	0	1	3	1	0	0	0	0	0	0	3	0	3	0	0	0	0	0	1	0	1	0	0	1	0	0	0
7	Belgium	38	1	4	7	8	0	24	5	1	2	2	0	0	0	0	0	0	2	0	0	0	3	1	0	0	0	0	0	2	0	2	0	1
8	Netherlands	23	5	3	4	6	1	2	34	1	3	1	2	0	0	1	1	0	1	1	0	0	6	0	0	0	1	0	1	3	0	2	1	0
9	Switzerland	32	3	9	3	7	0	0	0	23	3	3	0	2	0	0	2	0	2	1	1	0	2	3	0	0	1	0	0	2	0	1	1	0
10	Italy	35	12	24	3	5	2	0	1	4	1	1	1	1	0	0	0	0	0	1	0	0	2	1	0	0	0	0	0	2	0	1	0	0
11	Spain	31	8	0	15	0	0	12	0	0	8	4	4	0	0	0	4	0	8	0	0	0	0	0	0	0	0	4	0	0	0	4	0	0
12	Other W./S. Europe	41	3	5	3	5	0	0	0	3	0	3	28	0	0	0	0	0	0	3	3	0	0	0	3	0	0	0	0	3	0	0	0	0
13	Denmark	44	7	3	1	3	0	1	3	0	1	0	0	22	1	0	0	1	0	0	3	0	1	3	1	0	1	0	0	0	0	0	0	0
14	Finland	25	8	6	10	6	2	2	2	0	0	0	0	2	20	0	0	0	2	2	0	0	2	2	0	0	0	0	0	4	0	6	0	0
15	Norway	40	6	7	1	3	0	0	1	0	1	0	1	1	0	28	0	0	0	0	0	0	1	1	0	0	0	0	1	3	0	0	0	0
16	Sweden	31	3	3	4	6	0	0	0	0	2	1	1	0	1	2	38	1	2	2	0	0	0	1	0	0	0	0	0	2	1	0	0	0
17	Poland	29	2	5	6	7	3	0	1	2	1	0	1	0	0	1	1	29	1	1	0	0	2	0	0	1	0	0	0	2	1	1	4	1
18	Other E. Europe	23	6	2	8	8	1	2	2	2	4	4	1	0	1	0	2	0	25	2	0	0	1	2	0	0	0	1	0	1	0	1	0	1
19	Israel	50	3	6	3	3	0	1	1	1	0	0	1	0	1	0	1	0	1	21	2	1	2	0	0	0	0	0	3	0	0	0	0	0
20	Russia	37	3	6	9	8	0	1	3	1	3	5	0	1	0	0	0	2	0	2	16	1	3	0	1	0	0	0	1	0	0	0	0	0
21	Other former USSR	40	8	4	4	8	4	0	0	0	0	0	0	0	0	0	0	4	0	0	4	20	4	0	0	0	0	0	0	0	0	0	0	0
22	Japan	33	2	5	8	6	0	0	1	1	1	1	0	1	0	0	1	0	2	0	0	0	33	2	0	0	0	0	0	0	0	0	0	0
23	China	31	5	5	4	5	0	0	1	1	3	1	2	0	0	0	1	1	2	2	0	0	6	26	0	0	0	0	1	0	0	1	0	1
24	Taiwan	39	5	5	6	2	0	0	0	2	2	3	0	0	0	2	2	0	2	0	0	0	3	2	23	0	0	2	2	3	0	0	0	0
25	South Korea	57	0	3	3	6	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	17	0	0	0	6	0	0	0	0
26	Singapore	34	2	6	0	10	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	2	8	2	0	26	2	0	2	0	2	0	0
27	Hong Kong	53	3	10	0	0	0	0	0	0	3	0	3	0	0	0	0	0	0	3	0	0	3	0	0	0	0	13	0	7	0	0	0	0
28	India	39	5	3	0	5	0	0	0	0	2	0	0	2	2	0	0	0	0	2	0	0	3	3	2	0	0	0	31	0	3	0	0	0
29	Australia	40	6	8	3	3	1	0	3	2	1	1	1	1	0	0	0	0	1	1	1	1	3	3	1	0	1	0	1	22	0	0	0	1
30	New Zealand	48	4	4	0	4	0	4	4	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	17	0	4	0
31	Brazil	36	5	3	3	4	0	3	0	1	4	1	1	0	1	0	0	1	0	3	0	0	1	1	0	0	0	0	0	1	0	29	0	1
32	Other C. & S. America	38	5	4	4	1	0	1	1	1	3	1	1	0	3	0	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0	0	30	0
33	All other countries	28	5	3	8	7	0	0	1	0	5	1	0	1	1	0	0	0	1	3	0	0	2	2	1	0	1	0	2	2	1	0	0	23

NOTE: Listed countries received at least 0.3 percent of all citations for all natural science and engineering fields combined.

SOURCES: Institute for Scientific Information, Science Citation Index; CHI Research, Inc., Science Indicators database; and National Science Foundation, unpublished tabulations.

See figure 5-29

Appendix table 5-56.

Citations on U.S. patents to the U.S. scientific and technical literature, by field and cited sector: 1988-96

Citing year and cited sector	Total	Clinical medicine	Biomedical research	Biology	Chemistry	Physics	Earth & space sciences	Engineering & technology	Mathe-matics
Number of citations									
1988—Total U.S.	9,495	2,423	2,749	220	1,212	1,595	81	1,211	2
Academia	4,695	1,309	1,654	148	703	465	40	372	1
Industry	2,465	254	323	22	353	804	16	690	1
Federal Government	961	326	303	42	70	128	12	77	0
FFRDCs	340	18	44	0	46	179	5	46	0
Nonprofits	908	457	375	5	34	13	1	21	0
Other	123	57	48	2	3	4	5	3	0
1990—Total U.S.	12,906	3,417	3,818	306	1,673	2,169	76	1,443	3
Academia	6,436	1,853	2,218	201	939	727	30	463	2
Industry	3,448	408	558	30	571	1,068	27	783	0
Federal Government	1,188	422	405	64	56	154	9	76	0
FFRDCs	418	27	55	1	50	189	4	88	1
Nonprofits	1,240	618	517	5	50	25	4	19	0
Other	174	86	62	3	4	3	0	12	0
1992—Total U.S.	19,404	5,294	6,949	436	2,451	2,667	92	1,494	18
Academia	9,982	2,855	3,829	294	1,513	905	47	528	8
Industry	4,552	664	1,053	53	683	1,294	25	769	7
Federal Government	1,898	642	862	63	105	151	8	62	2
FFRDCs	592	41	110	1	88	257	6	85	1
Nonprofits	2,068	948	967	11	57	46	1	36	0
Other	312	144	128	14	5	14	5	14	0
1994—Total U.S.	27,422	7,223	10,334	675	3,114	3,589	121	2,349	14
Academia	14,535	3,989	5,852	453	1,968	1,258	53	947	11
Industry	6,443	936	1,713	94	839	1,710	35	1,111	1
Federal Government	2,519	907	1,087	96	98	200	16	113	0
FFRDCs	808	74	150	4	114	338	4	121	1
Nonprofits	2,727	1,131	1,372	19	84	73	4	42	0
Other	390	186	160	9	11	10	9	15	1
1996—Total U.S.	47,059	13,630	20,617	1,344	4,533	3,498	193	3,215	25
Academia	25,814	7,451	11,565	922	2,951	1,384	101	1,421	14
Industry	9,713	1,856	3,392	180	1,099	1,634	57	1,481	9
Federal Government	4,466	1,674	2,139	181	165	162	17	124	1
FFRDCs	958	114	305	9	139	264	10	114	0
Nonprofits	5,353	2,173	2,897	35	153	45	6	42	1
Other	755	362	319	17	26	9	2	33	0
Distribution of citations across fields, by sector (percentages)									
1988—Total U.S.	100	26	29	2	13	17	1	13	0
Academia	100	28	35	3	15	10	1	8	0
Industry	100	10	13	1	14	33	1	28	0
Federal Government	100	34	32	4	7	13	1	8	0
FFRDCs	100	5	13	0	14	53	1	14	0
Nonprofits	100	50	41	1	4	1	0	2	0
Other	100	46	39	2	2	3	4	2	0
1990—Total U.S.	100	26	30	2	13	17	1	11	0
Academia	100	29	34	3	15	11	0	7	0
Industry	100	12	16	1	17	31	1	23	0
Federal Government	100	36	34	5	5	13	1	6	0
FFRDCs	100	6	13	0	12	45	1	21	0
Nonprofits	100	50	42	0	4	2	0	2	0
Other	100	49	36	2	2	2	0	7	0

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Appendix table 5-56.

Citations on U.S. patents to the U.S. scientific and technical literature, by field and cited sector: 1988-96

Citing year and cited sector	Total	Clinical medicine	Biomedical research	Biology	Chemistry	Physics	Earth & space sciences	Engineering & technology	Mathematics
1992—Total U.S.	100	27	36	2	13	14	0	8	0
Academia	100	29	38	3	15	9	0	5	0
Industry	100	15	23	1	15	28	1	17	0
Federal Government	100	34	45	3	6	8	0	3	0
FFRDCs	100	7	19	0	15	43	1	14	0
Nonprofits	100	46	47	1	3	2	0	2	0
Other	100	46	41	4	2	4	2	4	0
1994—Total U.S.	100	26	38	2	11	13	0	9	0
Academia	100	27	40	3	14	9	0	7	0
Industry	100	15	27	1	13	27	1	17	0
Federal Government	100	36	43	4	4	8	1	4	0
FFRDCs	100	9	19	0	14	42	0	15	0
Nonprofits	100	41	50	1	3	3	0	2	0
Other	100	48	41	2	3	3	2	4	0
1996—Total U.S.	100	29	44	3	10	7	0	7	0
Academia	100	29	45	4	11	5	0	6	0
Industry	100	19	35	2	11	17	1	15	0
Federal Government	100	37	48	4	4	4	0	3	0
FFRDCs	100	12	32	1	15	28	1	12	0
Nonprofits	100	41	54	1	3	1	0	1	0
Other	100	48	42	2	3	1	0	4	0
1988—Total U.S.	100	100	100	100	100	100	100	100	100
Academia	49	54	60	67	58	29	49	31	50
Industry	26	10	12	10	29	50	20	57	50
Federal Government	10	13	11	19	6	8	15	6	0
FFRDCs	4	1	2	0	4	11	6	4	0
Nonprofits	10	19	14	2	3	1	1	2	0
Other	1	2	2	1	0	0	6	0	0
1990—Total U.S.	100	100	100	100	100	100	100	100	100
Academia	50	54	58	66	56	34	39	32	67
Industry	27	12	15	10	34	49	36	54	0
Federal Government	9	12	11	21	3	7	12	5	0
FFRDCs	3	1	1	0	3	9	5	6	33
Nonprofits	10	18	14	2	3	1	5	1	0
Other	1	3	2	1	0	0	0	1	0
1992—Total U.S.	100	100	100	100	100	100	100	100	100
Academia	51	54	55	67	62	34	51	35	44
Industry	23	13	15	12	28	49	27	51	39
Federal Government	10	12	12	14	4	6	9	4	11
FFRDCs	3	1	2	0	4	10	7	6	6
Nonprofits	11	18	14	3	2	2	1	2	0
Other	2	3	2	3	0	1	5	1	0

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Appendix table 5-56.

Citations on U.S. patents to the U.S. scientific and technical literature, by field and cited sector: 1988-96

Citing year and cited sector	Total	Clinical medicine	Biomedical research	Biology	Chemistry	Physics	Earth & space sciences	Engineering & technology	Mathematics
1994—Total U.S.	100	100	100	100	100	100	100	100	100
Academia	53	55	57	67	63	35	44	40	79
Industry	23	13	17	14	27	48	29	47	7
Federal Government	9	13	11	14	3	6	13	5	0
FFRDCs	3	1	1	1	4	9	3	5	7
Nonprofits	10	16	13	3	3	2	3	2	0
Other	1	3	2	1	0	0	7	1	7
1996—Total U.S.	100	100	100	100	100	100	100	100	100
Academia	55	55	56	69	65	40	52	44	56
Industry	21	14	16	13	24	47	30	46	36
Federal Government	9	12	10	13	4	5	9	4	4
FFRDCs	2	1	1	1	3	8	5	4	0
Nonprofits	11	16	14	3	3	1	3	1	4
Other	2	3	2	1	1	0	1	1	0

FFRDC = federally funded research and development center

NOTE: Percentages may not total 100 because of rounding.

SOURCES: CHI Research, Inc., U.S. Patent and Citation Indicators database; and National Science Foundation, unpublished tabulations.

See figure 5-30 and text table 5-13.

Appendix table 5-57.

U.S. patents awarded to U.S. universities and colleges with largest 1995 R&D volume and to other academic institutions: 1982-95

Institution	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Number of patents														
All academic institutions[a]	458	434	551	588	670	819	813	1225	1176	1331	1533	1607	1762	1860
Public	241	224	259	307	357	396	407	655	670	794	908	940	1067	1190
Private	217	210	292	281	313	423	406	570	506	537	625	667	695	670
Top 100 in 1995 R&D[b]	354	334	407	449	510	662	665	1003	975	1108	1291	1351	1483	1561
Public	203	191	217	262	300	344	353	559	571	671	776	805	912	1022
Private	151	143	190	187	210	318	312	444	404	437	515	546	571	539
Percent of all patents awarded	77	77	74	76	76	81	82	82	83	83	84	84	84	84
Number of academic institutions awarded patents														
All academic institutions[a]	73	83	102	113	121	124	122	153	147	154	152	163	167	168
Public	43	52	56	64	75	70	70	90	87	94	93	101	101	103
Private	30	31	46	49	46	54	52	63	60	60	59	62	66	65
Top 100 in 1995 R&D[b]	51	56	64	71	74	77	76	83	84	85	83	85	87	86
Public	30	35	38	45	48	48	47	52	54	56	54	55	56	55
Private	21	21	26	26	26	29	29	31	30	29	29	30	31	31
Top 100—public														
Arizona State University	0	0	1	1	1	2	0	9	9	12	6	2	3	6
Auburn University	0	0	0	1	1	0	0	0	2	1	5	0	2	2
Clemson University	0	0	2	2	1	3	3	6	6	2	10	4	10	8
Colorado State University	0	0	0	1	3	4	2	0	2	4	1	4	1	1
Florida State University	0	0	1	0	2	2	1	1	1	1	2	9	5	10
Georgia Institute of Technology	8	3	6	11	9	9	7	8	18	11	16	16	20	21
Indiana University	0	3	2	4	0	3	1	6	1	3	6	1	7	6
Iowa State University	15	10	14	21	9	15	15	28	30	39	23	29	37	37
Louisiana State University	0	1	1	1	1	3	4	9	4	5	20	16	11	14
Michigan State University	1	3	3	3	10	6	8	2	7	11	19	13	21	15
New Mexico State University	0	2	0	0	1	2	0	0	0	1	0	2	4	0
North Carolina State University	1	0	2	3	4	6	5	10	14	11	24	27	32	31
Ohio State University	6	9	3	12	5	13	14	13	10	15	21	10	10	17
Oklahoma State University	0	0	0	0	2	0	2	1	1	1	2	0	0	3
Oregon State University	0	1	0	2	3	0	2	1	1	6	9	5	11	6
Pennsylvania State University	0	0	0	0	0	0	0	1	1	1	0	4	11	16
Purdue University	11	11	14	18	9	4	2	11	15	11	5	6	11	10
Rutgers University	0	0	1	1	0	2	2	7	2	15	12	15	18	20
SUNY	8	2	11	5	11	18	10	25	20	27	34	30	37	31
Texas A&M University	3	2	3	8	3	6	9	8	9	12	14	22	20	16
University of Alabama	3	1	1	5	3	5	3	3	6	3	7	6	7	9
University of Arizona	1	2	1	2	2	0	0	1	2	1	1	4	9	10
University of California	42	48	46	42	54	67	60	81	65	84	81	115	163	213
University of Cincinnati	0	0	2	2	1	8	3	8	9	9	7	8	7	8
University of Colorado	0	0	0	0	0	1	0	3	9	6	19	7	14	18

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Appendix table 5-57.

U.S. patents awarded to U.S. universities and colleges with largest 1995 R&D volume and to other academic institutions: 1982-95

Institution	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Top 100—public														
University of Connecticut	0	0	0	1	1	2	1	2	8	3	9	9	2	8
University of Florida	0	6	10	7	10	13	21	33	33	38	41	34	26	31
University of Georgia	0	7	7	5	6	3	0	3	5	8	10	18	7	10
University of Hawaii	1	1	0	2	0	1	3	2	6	2	5	8	6	7
University of Health Sciences/Chicago	0	0	0	0	2	1	1	1	0	0	0	1	0	0
University of Illinois	7	8	8	10	12	4	9	15	7	8	10	13	14	12
University of Iowa	0	0	0	0	0	0	0	0	0	0	0	0	0	0
University of Kansas	0	2	2	1	0	2	0	1	3	4	7	3	2	2
University of Kentucky	6	6	7	5	7	4	7	6	4	7	7	4	3	11
University of Maryland	0	1	0	0	3	2	2	1	4	4	14	21	15	20
University of Massachusetts	0	0	1	1	0	2	1	3	3	6	5	4	5	12
Univ. of Medicine & Dentistry of NJ	1	1	0	1	4	7	2	4	7	2	6	1	4	5
University of Michigan	2	2	1	1	10	6	14	23	27	21	21	19	28	30
University of Minnesota	10	5	6	11	16	28	26	40	38	32	31	27	28	25
University of Missouri	9	5	4	0	3	8	9	5	6	7	9	8	7	10
University of Nebraska	4	0	5	1	1	1	4	0	3	4	4	10	16	21
University of New Mexico	0	0	0	2	3	1	3	9	9	10	11	5	9	15
University of North Carolina	0	1	0	0	3	2	2	6	8	3	11	14	13	21
University of Oklahoma	2	1	2	5	2	2	6	4	7	3	7	14	8	11
University of Pittsburgh	2	5	8	3	8	10	6	11	11	16	10	10	10	13
University of South Carolina	1	0	2	1	1	0	4	2	0	4	6	2	3	0
University of South Florida	0	0	0	0	1	0	0	2	2	7	5	7	4	6
University of Tennessee	1	0	1	5	8	8	8	12	14	10	12	4	5	14
University of Texas	7	5	8	19	25	21	21	50	54	83	73	86	97	89
Univ. of Texas Anderson Cancer Ctr.	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Univ. of TX SW Medical Ctr. Dallas	0	0	0	0	0	0	0	0	0	0	0	0	0	1
University of Utah	14	15	9	11	7	12	9	13	14	5	13	20	22	17
University of Virginia	8	4	2	1	4	3	4	8	12	11	9	7	5	10
University of Washington	7	2	3	1	2	1	6	5	7	11	12	11	13	17
University of Wisconsin	17	13	16	17	17	11	20	27	16	44	42	56	48	47
Utah State University	0	0	1	3	2	2	1	1	2	3	2	2	2	8
Virginia Commonwealth University	0	0	0	0	0	0	0	0	1	1	3	6	4	2
Virginia Polytechnic Institute	0	0	0	0	0	0	2	7	4	11	18	12	16	6
Washington State University	3	2	0	2	2	2	1	5	3	3	3	2	4	4
Wayne State University	2	1	0	1	5	6	7	16	9	8	16	12	14	9

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Appendix table 5-57

U.S. patents awarded to U.S. universities and colleges with largest 1995 R&D volume and to other academic institutions: 1982-95

Institution	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Top 100—private														
Baylor College of Medicine	3	1	2	2	2	7	3	7	8	4	6	9	9	4
Boston University	1	2	2	3	6	9	9	9	11	6	22	15	14	14
California Institute of Technology	19	16	15	16	23	27	18	56	30	36	32	29	46	38
Carnegie-Mellon University	0	0	3	3	3	1	2	5	3	5	10	4	8	10
Case Western Reserve University	0	0	1	1	6	3	1	1	2	1	9	6	8	8
Columbia University	0	2	3	4	7	6	15	19	16	8	17	17	18	18
Cornell University	6	10	14	20	13	30	16	22	34	40	41	35	39	36
Duke University	3	3	6	4	6	4	9	11	7	6	9	12	29	20
Emory University	0	0	0	1	1	0	0	7	3	10	6	14	5	11
Georgetown University	1	4	5	1	0	4	3	1	5	3	5	5	7	6
Harvard University	11	10	7	1	2	9	17	15	23	9	16	17	16	14
Johns Hopkins University	8	6	10	15	18	18	21	27	15	25	20	33	23	28
Massachusetts Inst. of Technology	51	47	47	35	45	63	64	101	109	101	125	112	99	104
Mount Sinai School of Medicine	4	3	2	1	2	1	2	1	2	5	3	3	4	4
New York University	7	3	4	5	3	5	4	10	14	8	11	19	16	15
Northwestern University	7	3	2	2	8	10	10	7	5	4	8	8	12	18
Princeton University	0	0	0	0	0	2	1	12	4	13	4	11	7	12
Rockefeller University	3	1	3	5	4	9	11	6	8	14	23	23	13	9
Stanford University	4	16	36	38	33	48	54	43	36	57	42	50	62	54
Tufts University	0	0	0	0	0	1	2	7	1	5	7	9	6	3
Tulane University	0	0	1	2	1	1	3	4	4	7	5	6	6	5
University of Chicago	2	0	2	0	0	1	6	7	2	0	0	6	14	16
University of Miami	2	0	4	4	3	15	5	5	1	1	5	2	5	5
University of Pennsylvania	1	2	4	5	1	2	1	9	19	18	26	34	37	25
University of Rochester	8	9	6	2	8	9	11	11	13	12	10	11	10	6
University of Southern California	5	1	7	5	5	4	7	8	6	5	18	13	15	6
Vanderbilt University	2	1	0	0	5	4	4	4	5	7	4	7	6	9
Washington University	0	1	1	3	1	7	6	12	7	22	18	18	19	21
Woods Hole Oceanographic Inst.	0	0	0	0	0	0	0	1	0	1	0	0	2	1
Yale University	0	2	2	5	3	12	6	11	10	4	12	14	13	16
Other public institutions														
Ball State University	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Bowling Green State University	0	0	0	1	0	0	1	1	1	0	0	0	0	0
California Polytechnic State Univ.	0	0	0	0	0	0	0	0	0	0	0	0	0	1
California State University Fresno	0	0	0	0	0	0	0	0	0	0	0	1	0	3
California State University Fullerton	0	0	0	0	0	0	0	1	0	0	0	0	0	0
City College of New York	0	0	0	0	0	0	0	0	0	0	1	0	1	1
City University of New York	0	0	0	0	0	0	1	1	0	0	0	0	0	1
Cleveland State University	0	0	0	0	0	0	0	0	0	0	3	4	3	0
College of Forestry, Wildlife & Range Sciences, Univ. of Idaho	0	1	0	0	0	0	0	0	0	0	0	0	0	0

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Appendix table 5-57.

U.S. patents awarded to U.S. universities and colleges with largest 1995 R&D volume and to other academic institutions: 1982-95

Institution	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Colorado School of Mines	0	0	0	2	1	0	0	2	2	2	2	1	1	2
East Carolina University	0	0	0	0	0	0	0	0	1	1	1	1	1	1
East Tennessee State University	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Eastern Washington University	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Florida Agricultural & Mechanical Univ.	0	0	0	0	1	0	1	0	0	0	0	0	0	0
Florida Atlantic University	0	0	0	0	0	0	0	0	0	1	0	3	3	1
Florida International University	0	0	0	0	0	0	0	0	2	0	1	1	0	0
Fort Valley State College	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Georgia State University	0	0	0	0	0	0	0	0	2	0	1	1	2	1
Grand Valley State University	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Hahnemann University	0	0	2	0	0	0	0	0	0	0	2	1	0	0
Illinois State University	0	0	0	0	0	0	0	2	1	0	1	0	0	0
James Madison University	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Kansas State University	2	4	3	2	4	4	3	4	1	7	7	9	20	11
Kent State University	0	0	0	0	0	1	0	0	1	3	2	3	3	4
Medical College of Georgia	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Medical College of Ohio	0	1	0	2	0	4	1	0	1	2	0	0	0	2
Medical University of South Carolina	0	0	0	0	1	0	1	0	1	0	0	0	1	2
Memphis State University	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Miami University	0	1	0	0	0	0	2	0	0	0	0	0	0	0
Michigan Technological University	2	4	7	6	2	1	2	1	5	6	6	3	3	2
Mississippi State University	0	0	0	0	0	0	0	0	0	0	0	1	1	2
Montana State University	3	2	2	1	1	0	0	1	3	2	1	0	4	2
Montclair State College	0	0	0	0	0	0	0	0	1	0	0	0	0	0
New Jersey Institute of Technology	0	0	0	1	0	0	0	2	0	1	2	0	1	2
New Mexico Inst. of Mining & Tech.	0	0	0	0	2	1	0	0	0	0	1	0	3	2
North Carolina Central University	0	0	0	1	0	0	0	0	0	2	0	1	0	0
North Dakota State University	0	0	2	0	0	0	0	2	0	2	2	3	1	5
Northeast University of Technology	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Northeastern Ohio Universities College of Medicine	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Northern Illinois University	0	0	0	0	0	0	1	0	0	1	0	2	2	1
Nova University	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Oak Ridge Associated Universities	0	0	0	0	0	0	1	2	0	0	1	0	0	0
Ohio University	0	0	0	0	1	1	0	1	0	4	3	3	3	5
Old Dominion University	0	0	0	0	0	0	0	0	0	0	0	1	2	0
Oregon Health Sciences University	0	0	0	0	0	3	0	3	4	6	5	5	6	10
Pennsylvania Research Corporation	0	0	0	0	0	1	1	0	2	5	7	6	5	2
Portland State University	0	0	1	0	1	1	0	0	0	0	0	0	0	0
Saginaw Valley State University	0	0	0	0	0	0	1	1	0	1	0	0	1	0
South Dakota School of Mines	0	0	0	1	0	0	0	0	0	0	1	0	2	0

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Appendix table 5-57.

U.S. patents awarded to U.S. universities and colleges with largest 1995 R&D volume and to other academic institutions: 1982-95

Institution	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Southeastern Illinois College	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Temple University	2	0	2	0	1	5	7	10	9	3	14	9	9	11
Texas Tech University	0	0	0	0	2	1	2	0	0	1	1	0	0	1
University of Iowa	5	3	4	1	8	8	6	8	12	6	7	11	9	17
University of Akron	4	1	3	3	2	0	6	6	9	14	11	9	17	11
University of Alaska	0	0	0	0	0	0	0	0	0	1	1	1	3	2
University of Arkansas	0	0	0	0	1	1	1	2	3	10	16	8	10	5
University of Central Florida	0	0	0	0	0	0	0	1	0	0	0	4	4	6
University of Delaware	12	6	5	9	7	5	8	8	11	10	10	5	4	5
University of Houston	0	0	0	0	1	0	0	3	3	4	1	3	5	8
University of Louisville	0	0	0	0	0	0	0	0	1	0	0	1	1	2
University of Lowell	0	0	0	0	0	0	0	2	1	2	3	1	1	0
University of Maine	2	2	2	3	1	0	0	1	1	0	0	0	0	0
Univ. of Maryland Eastern Shore	0	0	0	0	0	0	0	0	0	0	0	0	0	1
University of Minneapolis	0	0	0	0	0	0	0	0	0	0	0	1	0	0
University of Mississippi	1	0	1	0	0	1	0	2	0	0	1	2	0	2
University of Montana	0	0	0	0	1	0	0	0	0	0	0	1	1	2
University of Nevada	0	0	0	0	0	0	0	0	0	0	1	0	1	0
University of New Hampshire	0	0	0	0	1	0	0	1	0	1	0	0	1	0
University of New Orleans	0	0	0	0	0	0	0	0	0	0	0	0	1	0
University of North Dakota	0	0	0	0	0	0	0	0	3	4	1	2	1	1
University of Northern Iowa	0	0	1	0	1	0	0	0	0	0	0	1	0	0
University of Oregon	0	1	0	0	0	0	0	2	0	0	3	2	3	2
University of Puerto Rico	0	0	0	0	0	0	0	0	0	1	0	1	0	4
University of Rhode Island	0	1	2	2	2	2	3	4	3	3	0	0	0	0
University of South Alabama	0	0	0	1	3	0	0	2	0	1	0	4	2	1
University of Southern Illinois	0	0	1	0	0	0	1	1	2	1	1	1	0	0
University of Southern Mississippi	0	2	0	0	3	3	1	1	3	4	1	2	0	1
University of Southwestern Louisiana	0	0	0	0	1	0	0	2	1	0	0	0	0	0
University of Toledo	2	1	2	0	1	0	0	3	0	2	4	7	6	14
University of Vermont	0	0	0	0	0	1	1	4	4	2	4	1	1	1
University of Wisconsin-Milwaukee	0	0	0	0	0	0	0	0	0	1	1	1	0	1
University of Wyoming	0	0	0	0	0	1	0	0	0	0	0	0	0	2
West Virginia University	0	0	0	1	0	2	0	2	1	1	0	0	1	2
Western Kentucky University	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Western Michigan University	1	0	0	0	0	0	0	0	0	2	0	1	1	0
Western Washington University	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Wichita State University	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Wright State University	1	1	1	6	6	4	2	3	3	3	1	4	3	0

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Appendix table 5-57.

U.S. patents awarded to U.S. universities and colleges with largest 1995 R&D volume and to other academic institutions: 1982-95

Institution	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Other private institutions														
Adelphi University	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Albany Medical College	0	0	0	0	0	0	0	1	1	0	0	1	0	0
Alfred University	0	1	5	3	1	1	0	1	6	5	5	6	4	3
Ambassador College	0	0	0	0	0	0	0	1	1	1	0	1	0	0
American University	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Baylor University	0	1	0	1	0	0	0	1	0	2	3	2	2	3
Boston College	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Brandeis University	0	0	1	0	0	1	1	9	4	5	4	2	2	3
Brigham Young University	0	1	3	3	6	2	1	8	9	5	9	13	3	3
Brooklyn College Foundation	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Brown University	0	0	1	2	2	1	3	3	3	4	5	1	4	6
Catholic University of America	0	0	0	0	0	0	0	0	0	0	0	1	3	4
Chapman College	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Clark University	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Clarkson University	0	0	0	0	0	0	0	0	0	1	0	0	1	0
College of Aeronautics, Brooklyn	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Concordia University	0	0	0	0	0	0	0	2	1	0	1	0	1	0
Cooperative Institute for Research in Environmental Sciences	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Creighton University	0	0	0	0	0	0	0	0	0	0	0	0	3	1
Dartmouth College	0	2	0	2	1	0	3	2	4	1	1	4	4	3
Davidson College	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Drexel University	0	0	0	0	0	0	0	3	2	2	2	5	6	4
Duquesne University	0	0	0	0	0	0	0	0	0	0	1	0	1	3
Eastern Virginia Medical School	0	0	0	0	0	0	0	0	0	0	0	1	0	0
General Motors Institute	0	0	0	0	1	1	0	4	0	1	1	0	1	0
George Washington University	0	1	0	2	0	0	0	1	0	0	1	2	0	0
Goshen College	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Howard University	0	0	0	0	0	0	0	0	0	0	0	2	0	3
Illinois Institute of Technology	0	0	0	0	0	1	0	0	0	2	1	4	0	7
Lehigh University	1	0	2	0	2	5	1	5	4	6	7	4	3	1
Loma Linda University	0	0	0	1	0	0	0	1	2	2	1	2	2	8
Loyola University of Chicago	0	0	0	0	1	0	0	0	1	1	1	3	1	3
Marquette University	0	0	0	1	0	0	0	0	0	0	0	0	0	2
Mayo Foundation	0	0	0	3	1	1	0	3	4	4	8	9	4	6
Medical College of Hampton Roads	0	0	0	1	0	1	1	0	0	0	2	1	1	1
Medical College of Pennsylvania	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Medical College of Wisconsin	0	0	4	3	3	1	10	2	1	1	0	0	3	4
Mercer University	0	0	0	0	0	0	0	0	0	0	0	0	0	1

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Appendix table 5-57.

U.S. patents awarded to U.S. universities and colleges with largest 1995 R&D volume and to other academic institutions: 1982-95

Institution	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Milwaukee School of Engineering	0	0	0	0	0	0	0	0	0	1	0	0	0	0
New York Chiropractic College	0	0	0	0	0	0	0	0	1	0	0	0	0	0
New York Institute of Technology	4	0	2	3	7	7	4	3	1	1	2	0	1	0
New York Medical College	0	0	0	0	0	0	1	2	1	1	0	0	2	0
Northeastern University	1	0	0	3	2	2	1	3	4	6	11	10	15	16
Oregon Graduate Center	1	2	3	3	1	2	1	5	1	1	2	0	0	0
Polytechnic University	0	0	0	0	0	2	2	3	3	2	1	1	0	1
Regis College	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Rensselear Polytechnic Institute	4	0	4	5	6	2	2	5	4	2	2	7	7	7
Rice University	0	0	1	0	0	0	0	0	1	0	0	2	2	0
Roanoke College	0	0	1	2	1	1	1	0	1	0	0	0	0	0
Rochester Institute of Technology	0	0	0	0	0	1	0	0	0	0	0	0	1	0
Siena College	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Smith College	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Southern Methodist University	0	0	0	0	1	1	0	0	0	0	0	0	0	0
St. Johns University	0	0	0	1	0	0	0	1	0	0	0	0	0	0
Stevens Institute of Technology	0	0	0	0	0	0	4	0	1	2	0	0	1	1
St. Louis University	0	0	1	0	1	1	1	0	0	2	1	0	0	1
Syracuse University	0	0	1	2	3	2	5	4	9	2	5	5	3	1
Texas College of Osteopathic Medi.	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Texas Wesleyan University	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Thomas Jefferson University	2	4	10	5	3	3	2	7	5	7	8	9	13	14
Touro College	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Trinity University	0	0	1	0	0	0	0	0	0	0	0	0	2	0
Tuskegee University	0	0	0	0	0	0	0	1	0	0	0	1	0	0
University of Dayton	2	1	2	2	7	5	6	3	5	5	1	3	2	4
University of Denver	0	0	1	0	0	0	0	0	0	0	0	0	0	1
University of Hartford	0	0	0	0	0	0	0	0	0	0	0	1	0	0
University of New England	0	0	0	0	0	0	0	0	0	0	0	0	0	1
University of Notre Dame	0	0	0	1	2	1	2	2	0	3	1	2	3	0
University of Scranton	0	0	0	1	0	0	0	0	0	0	0	0	0	0
University of The Pacific	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Wabash College	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Wake Forest University	0	0	0	0	0	2	3	3	0	1	0	3	4	1
Worcester Polytechnic Institute	1	0	0	0	0	0	0	0	1	0	4	1	2	3
Affiliated organizations[b]	49	52	56	43	51	57	37	34	19	20	17	11	15	9

NOTE: Recording of patents to universities and colleges is not uniform. In some cases, patents may be issued to a systemwide board, rather than to individual institutions within the system. Thus, the institution counts are lower bound numbers.

[a] Data exclude a small number of unaffiliated organizations holding university patents.

[b] Data include organizations holding academic patents but not affiliated with a single institution, such as the Research Triangle Institute, Research Corporation, etc.

SOURCES: U.S. Patent and Trademark Office, *Technology Assessment and Forecast Report, U.S. Universities and Colleges, 1969-95* (Washington, DC: 1996); and National Science Foundation, unpublished tabulations.

See figures 5-31 and 5-32.

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Appendix table 5-58.

Utility classes emphasized in patents assigned to U.S. universities and colleges: 1969-95 total

Utility class	Number of U.S. patents awarded		University Activity Index[a]	Cumulative percent of patents	
	Total	Academic		Total	Academic
Total, all utility classes	2,052,216	18,701	1.0	100	100
505 Superconductor technology: apparatus, material, process	1,371	148	11.8	0	1
435 Chemistry: molecular biology and microbiology	16,483	1,686	11.2	1	10
530 Chemistry: natural resins or derivatives; peptides, proteins; lignins	4,545	446	10.8	1	12
800 Multicellular living organisms and unmodified parts thereof	255	21	9.0	1	12
536 Organic compounds—part of the class 532-570 series	4,320	307	7.8	1	14
424 Drug, bio-affecting and body treating compositions	15,777	987	6.9	2	19
436 Chemistry: analytical and immunological testing	5,180	306	6.5	2	21
552 Organic compounds—part of the class 532-570 series	2,347	110	5.1	2	21
623 Prosthesis (i.e., artificial body members), aids, accessories	3,988	175	4.8	3	22
527 Synthetic resins or natural rubbers—part of the class 520 series	259	11	4.7	3	22
128 Surgery	14,999	618	4.5	3	26
260 Chemistry of carbon compounds	125	5	4.4	3	26
171 Unearthing plants or buried objects	310	12	4.2	3	26
514 Drug, bio-affecting and body treating compositions	41,293	1,593	4.2	5	34
372 Coherent light generators	6,729	255	4.2	6	36
607 Surgery: light, thermal, and electrical application	3,565	128	3.9	6	36
378 X-ray or gamma ray systems or devices	4,874	168	3.8	6	37
117 Single- and oriented-crystal, epitaxy growth processes; non-coating	2,042	70	3.8	6	38
136 Batteries: thermoelectric and photoelectric	1,933	61	3.5	6	38
127 Sugar, starch, and carbohydrates	875	24	3.0	6	38
204 Chemistry: electrical and wave energy	11,248	286	2.8	7	40
600 Surgery	2,707	68	2.8	7	40
556 Organic compounds—part of the class 532-570 series	4,364	109	2.7	7	41
606 Surgery	7,678	183	2.6	8	42
549 Organic compounds—part of the class 532-570 series	7,981	185	2.5	8	43
111 Planting	952	22	2.5	8	43
324 Electricity: measuring and testing	16,573	370	2.5	9	45
250 Radiant energy	21,565	470	2.4	10	47
356 Optics: measuring and testing	12,359	252	2.2	11	49
546 Organic compounds—part of the class 532-570 series	7,325	138	2.1	11	49
604 Surgery	13,703	253	2.0	12	51
419 Powder metallurgy processes	1,635	29	1.9	12	51
87 Textiles: braiding, netting, and lace making	227	4	1.9	12	51
47 Plant husbandry	2,869	49	1.9	12	51
216 Etching a substrate: processes	2,229	38	1.9	12	51
385 Optical waveguides	7,214	120	1.8	12	52
540 Organic compounds—part of the class 532-570 series	6,407	106	1.8	13	52
460 Crop threshing or separating	667	11	1.8	13	53
382 Image analysis	4,139	68	1.8	13	53
257 Active solid-state devices (e.g., transistors, solid-state diodes)	13,852	222	1.8	13	54
359 Optics: systems (including communication) and elements	19,939	316	1.7	14	56
501 Compositions: ceramic	4,732	74	1.7	15	56
73 Measuring and testing	28,848	448	1.7	16	59
554 Organic compounds—part of the class 532-570 series	2,140	33	1.7	16	59
209 Classifying, separating, and assorting solids	5,445	83	1.7	16	59
205 Electrolysis: processes, compositions used, preparation methods	9,543	142	1.6	17	60
426 Food or edible material: processes, compositions, and products	14,440	211	1.6	18	61
95 Gas separation: processes	3,380	49	1.6	18	61
374 Thermal measuring and testing	2,994	43	1.6	18	62
44 Fuel and related compositions	2,736	39	1.6	18	62
427 Coating processes	15,384	219	1.6	19	63
71 Chemistry: fertilizers	1,228	17	1.5	19	63
351 Optics: eye examining, vision testing and correcting	2,789	38	1.5	19	63
437 Semiconductor device manufacturing: process	12,277	165	1.5	20	64
364 Electrical computers and data processing systems	21,708	290	1.5	21	66

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Appendix table 5-58.

Utility classes emphasized in patents assigned to U.S. universities and colleges: 1969-95 total

Utility class	Number of U.S. patents awarded		University Activity Index[a]	Cumulative percent of patents	
	Total	Academic		Total	Academic
588 Hazardous or toxic waste destruction or containment	988	13	1.4	21	66
210 Liquid purification or separation	21,094	277	1.4	22	67
423 Chemistry of inorganic compounds	15,547	204	1.4	23	68
422 Chemical apparatus, process disinfecting, deodorizing, preserving	9,738	126	1.4	23	69
522 Synthetic resins or natural rubbers—part of the class 520 series	1,555	19	1.3	23	69
449 Bee culture	166	2	1.3	23	69
528 Synthetic resins or natural rubbers—part of the class 520 series	13,579	163	1.3	24	70
534 Organic compounds—part of the class 532-570 series	2,701	32	1.3	24	70
343 Communications: radio wave antennas	4,393	52	1.3	24	70
602 Surgery: splint, brace, or bandage	2,408	28	1.3	24	71
333 Wave transmission lines and networks	6,147	70	1.3	25	71
429 Chemistry: electrical current producing apparatus, product, process	7,650	85	1.2	25	71
504 Plant protecting and regulating compositions	6,061	66	1.2	25	72
395 Information processing system organization	20,753	224	1.2	26	73
525 Synthetic resins or natural rubbers—part of the class 520 series	16,325	176	1.2	27	74
363 Electric power conversion systems	4,778	50	1.1	27	74
56 Harvesters	5,414	56	1.1	27	74
119 Animal husbandry	5,337	55	1.1	28	75
568 Organic compounds—part of the class 532-570 series	9,980	102	1.1	28	75
75 Specialized metallurgical processes, compositions for use	6,263	64	1.1	29	76
560 Organic compounds—part of the class 532-570 series	7,774	79	1.1	29	76
96 Gas separation: apparatus	2,169	22	1.1	29	76
148 Metal treatment	7,353	73	1.1	29	77
365 Static information storage and retrieval	9,770	96	1.1	30	77
548 Organic compounds—part of the class 532-570 series	8,572	84	1.1	30	78
601 Surgery: kinesitherapy	2,052	20	1.1	30	78
270 Sheet-material associating	1,233	12	1.1	30	78
502 Catalyst, solid sorbent, or support therefor: product or process	9,454	92	1.1	31	78
562 Organic compounds—part of the class 532-570 series	6,457	62	1.1	31	79
434 Education and demonstration	4,393	42	1.0	31	79
367 Communications, electrical: acoustic wave systems and devices	5,025	48	1.0	32	79
518 Chemistry: Fischer-Tropsch processes; purification or recovery	526	5	1.0	32	79
544 Organic compounds—part of the class 532-570 series	7,883	72	1.0	32	79
558 Organic compounds—part of the class 532-570 series	5,851	53	1.0	32	80
48 Gas: heating and illuminating	1,441	13	1.0	32	80
310 Electrical generator or motor structure	10,661	94	1.0	33	80
380 Cryptography	2,389	21	1.0	33	80
264 Plastic and nonmetallic article shaping or treating: processes	17,694	155	1.0	34	81
521 Synthetic resins or natural rubbers—part of the class 520 series	5,873	51	1.0	34	81
All others	1,350,222	3,462	0.4	66	19

NOTES: This table presents the number and title of selected classes of technology represented in the U.S. Patent Classification system as of December 31, 1995. Patent counts are the total number awarded to all assignees and to U.S. higher education institutions.

[a] The University Activity Index is calculated by dividing the proportion of university patents in a given class by the proportion of all patents in that class. Index values greater than 1.0 indicate technology classes that receive relatively greater emphasis in university patenting than elsewhere. Data are presented in declining order of importance.

SOURCES: U.S. Patent and Trademark Office, *Technology Assessment and Forecast Report, U.S. Universities and Colleges, 1969-95* (Washington, DC: 1996); and National Science Foundation, unpublished tabulations.

Appendix table 5-59.

Patents awarded to U.S. universities and colleges, by utility class: 1969-74 through 1991-95

	Number of patents					Percentage of patents				
Utility class	1969-74	1975-80	1981-85	1986-90	1991-95	1969-74	1975-80	1981-85	1986-90	1991-95
Total, all utility classes	1,374	2,064	2,467	4,703	8,093	100	100	100	100	100
435 Chemistry: molecular biology and microbiology	46	99	201	454	886	3	5	8	10	11
514 Drug, bio-affecting and body treating compositions	34	129	232	481	717	2	6	9	10	9
424 Drug, bio-affecting and body treating compositions	40	86	124	256	481	3	4	5	5	6
128 Surgery	34	61	79	158	286	2	3	3	3	4
250 Radiant energy	30	59	46	120	215	2	3	2	3	3
530 Chemistry: natural resins or derivatives; peptides or proteins; lignins or reaction products thereof	9	16	83	135	203	1	1	3	3	3
536 Organic compounds—part of the class 532-570 series	13	31	35	63	165	1	2	1	1	2
324 Electricity: measuring and testing	29	18	37	137	149	2	1	1	3	2
364 Electrical computers and data processing systems	11	19	26	88	146	1	1	1	2	2
73 Measuring and testing	59	69	71	104	145	4	3	3	2	2
204 Chemistry: electrical and wave energy	28	24	34	58	142	2	1	1	1	2
359 Optics: systems (including communication) and elements	26	35	31	83	141	2	2	1	2	2
427 Coating processes	7	11	15	55	131	1	1	1	1	2
395 Information processing system organization	18	13	13	51	129	1	1	1	1	2
257 Active solid-state devices (e.g., transistors, solid-state diodes)	7	19	17	53	126	1	1	1	1	2
210 Liquid purification or separation	24	36	32	59	126	2	2	1	1	2
604 Surgery	5	13	36	80	119	0	1	1	2	1
505 Superconductor technology: apparatus, material, process	0	0	0	29	119	0	0	0	1	1
372 Coherent light generators	13	19	29	77	117	1	1	1	2	1
436 Chemistry: analytical and immunological testing	13	61	67	61	104	1	3	3	1	1
428 Stock material or miscellaneous articles	12	16	32	50	96	1	1	1	1	1
356 Optics: measuring and testing	17	25	31	86	93	1	1	1	2	1
525 Synthetic resins or natural rubbers—part of the class 520 series	4	20	24	37	91	0	1	1	1	1
528 Synthetic resins or natural rubbers—part of the class 520 series	13	22	6	32	90	1	1	0	1	1
437 Semiconductor device manufacturing: process	3	13	26	43	80	0	1	1	1	1
423 Chemistry of inorganic compounds	26	41	27	30	80	2	2	1	1	1
606 Surgery	13	11	22	58	79	1	1	1	1	1
264 Plastic and nonmetallic article shaping or treating: processes	7	20	20	33	75	1	1	1	1	1
426 Food or edible material: processes, compositions, and products	24	39	39	35	74	2	2	2	1	1
549 Organic compounds—part of the class 532-570 series	4	32	37	40	72	0	2	1	1	1
546 Organic compounds—part of the class 532-570 series	9	28	9	29	63	1	1	0	1	1
378 X-ray or gamma ray systems or devices	16	30	23	36	63	1	1	1	1	1
623 Prosthesis (i.e., artificial body members), parts thereof, or aids and accessories therefor	20	15	21	59	60	1	1	1	1	1
252 Compositions	9	15	18	24	59	1	1	1	1	1
422 Chemical apparatus and process disinfecting, deodorizing, preserving, or sterilizing	7	14	13	34	58	1	1	1	1	1
205 Electrolysis: processes, compositions used therein, and methods of preparing the compositions	6	17	29	35	55	0	1	1	1	1
348 Television	11	10	4	32	53	1	0	0	1	1
556 Organic compounds—part of the class 532-570 series	9	8	13	26	53	1	0	1	1	1
502 Catalyst, solid sorbent, or support therefor: product or process of making	1	9	11	22	49	0	0	0	0	1
385 Optical waveguides	1	9	19	48	43	0	0	1	1	1
607 Surgery: light, thermal, and electrical application	5	17	20	44	42	0	1	1	1	1

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Appendix table 5-59.

Patents awarded to U.S. universities and colleges, by utility class: 1969-74 through 1991-95

Utility class	Number of patents					Percentage of patents				
	1969-74	1975-80	1981-85	1986-90	1991-95	1969-74	1975-80	1981-85	1986-90	1991-95
501 Compositions: ceramic	0	5	6	22	41	0	0	0	0	1
526 Synthetic resins or natural rubbers—part of the class 520 series	1	8	3	19	39	0	0	0	0	0
382 Image analysis	1	2	5	22	38	0	0	0	0	0
540 Organic compounds—part of the class 532-570 series	5	16	12	36	37	0	1	0	1	0
148 Metal treatment	2	10	12	14	35	0	0	0	0	0
318 Electricity: motive power systems	7	7	5	7	33	1	0	0	0	0
544 Organic compounds—part of the class 532-570 series	2	7	10	20	33	0	0	0	0	0
219 Electric heating	4	10	9	15	32	0	0	0	0	0
365 Static information storage and retrieval	23	9	7	25	32	2	0	0	1	0
548 Organic compounds—part of the class 532-570 series	3	15	9	25	32	0	1	0	1	0
568 Organic compounds—part of the class 532-570 series	13	29	14	15	31	1	1	1	0	0
504 Plant protecting and regulating compositions	3	8	4	20	31	0	0	0	0	0
All other utility classes	647	709	719	1,028	1,604	47	34	29	22	20

SOURCES: U.S. Patent and Trademark Office, *Technology Assessment and Forecast Report, U.S. Universities and Colleges, 1969-95* (Washington, DC: 1996); and National Science Foundation, unpublished tabulations.

See figure 5-33.

Appendix table 6-1.

Real gross domestic product, for selected countries: 1960-95

(Billions of 1995 U.S. dollars)

	United States	Canada	Japan	South Korea	Austria	Belgium	Denmark	France	Germany[a]	Italy	Nether-lands	Norway	Sweden	United Kingdom
1960	2,433.07	170.88	415.98	36.12	55.01	76.32	43.97	378.74	544.64	345.35	100.42	29.26	70.36	507.23
1961	2,484.81	176.24	476.54	38.23	57.93	80.11	46.56	399.60	569.86	373.69	103.33	31.04	74.36	520.29
1962	2,634.66	188.73	510.18	39.05	59.32	84.29	49.12	426.26	596.43	396.87	107.77	31.88	77.53	527.20
1963	2,747.51	198.52	563.76	42.62	61.74	87.96	49.35	449.05	613.21	419.14	111.33	33.08	81.66	548.05
1964	2,907.69	211.76	638.25	46.74	65.47	94.08	53.76	478.32	654.06	430.86	120.90	34.74	87.23	577.85
1965	3,092.62	225.73	671.01	49.42	67.34	97.43	56.34	501.18	689.08	444.94	127.31	36.58	90.56	592.48
1966	3,292.07	241.05	742.11	55.44	71.14	100.51	57.67	527.31	708.30	471.57	130.87	37.96	92.46	603.68
1967	3,378.13	248.12	822.07	58.71	73.28	104.40	59.64	552.03	706.12	505.42	137.81	40.34	95.57	617.52
1968	3,537.77	261.40	927.04	65.36	76.56	108.79	62.01	575.54	744.63	538.50	147.04	41.25	99.05	642.68
1969	3,644.70	275.40	1,040.77	74.42	81.36	116.01	65.93	615.77	800.18	571.34	157.04	43.11	104.01	655.93
1970	3,644.92	282.55	1,142.86	80.94	87.16	123.39	67.26	651.06	840.49	601.68	166.07	43.97	110.74	670.90
1971	3,765.30	298.82	1,193.03	87.81	91.61	127.92	69.06	682.20	866.19	613.08	173.46	45.98	111.79	684.23
1972	3,969.91	315.94	1,293.40	92.04	97.30	134.68	72.70	712.43	903.01	631.02	178.85	48.36	114.34	708.19
1973	4,197.97	340.31	1,397.29	103.82	102.06	142.64	75.34	751.19	946.04	672.30	187.88	50.34	118.88	760.31
1974	4,182.80	355.29	1,380.17	112.20	106.08	148.47	74.64	774.55	947.89	703.83	195.49	52.96	122.68	747.39
1975	4,157.95	364.53	1,422.84	119.64	105.70	146.26	74.15	772.39	936.02	688.72	195.78	55.17	125.82	742.01
1976	4,390.32	386.99	1,479.40	133.72	110.53	154.41	78.95	805.17	985.85	733.47	205.11	58.92	127.15	762.61
1977	4,603.54	400.98	1,544.35	147.51	115.55	155.15	80.23	831.07	1,013.90	754.67	209.90	61.03	125.12	780.63
1978	4,834.18	419.32	1,625.77	161.36	115.62	159.39	81.41	858.92	1,044.29	782.80	214.85	63.80	127.31	807.61
1979	4,974.35	435.55	1,714.93	172.87	121.10	162.79	84.30	886.76	1,088.41	827.21	219.63	67.04	132.20	830.20
1980	4,961.34	442.02	1,763.25	168.23	124.64	169.82	83.92	901.16	1,099.08	856.42	222.28	69.86	134.40	812.25
1981	5,082.90	458.25	1,819.15	178.67	124.28	167.06	83.18	911.76	1,100.17	860.48	221.16	70.47	134.39	801.77
1982	4,973.92	443.51	1,874.76	192.23	125.61	169.83	85.69	934.97	1,089.82	864.42	218.58	70.70	135.73	815.63
1983	5,174.45	457.54	1,918.30	214.33	128.11	170.08	87.85	941.47	1,108.99	874.95	222.32	73.98	138.11	845.62
1984	5,527.51	486.40	1,993.44	232.93	129.85	173.81	91.70	953.84	1,140.20	897.42	229.63	78.23	143.70	865.27
1985	5,733.31	509.59	2,081.24	248.18	133.05	175.10	95.64	971.79	1,163.35	922.64	236.70	82.36	146.47	897.76
1986	5,905.86	526.49	2,141.50	276.86	134.62	177.96	99.12	996.26	1,190.63	948.84	243.22	85.80	149.83	936.21
1987	6,076.37	548.42	2,230.56	308.75	136.85	181.74	99.41	1,018.68	1,208.23	978.22	246.66	87.51	154.55	981.27
1988	6,307.12	575.73	2,368.74	343.55	142.41	190.69	100.57	1,064.50	1,253.21	1,016.06	253.11	87.07	158.03	1,030.37
1989	6,519.59	589.81	2,483.18	365.48	147.86	197.26	101.14	1,109.77	1,298.64	1,045.35	264.96	87.86	161.78	1,052.86
1990	6,603.82	588.43	2,609.42	400.23	154.14	204.52	102.58	1,137.60	1,372.71	1,067.96	275.84	89.50	163.99	1,057.04
1991	6,539.60	577.91	2,713.01	436.78	158.52	207.74	103.96	1,146.48	1,441.98	1,080.12	282.11	92.29	162.16	1,036.31
1992	6,717.53	582.33	2,741.60	458.91	161.75	211.25	104.20	1,159.81	1,467.42	1,086.22	287.82	95.31	159.85	1,030.82
1993	6,870.29	595.26	2,745.11	485.30	162.34	208.39	105.74	1,144.38	1,438.83	1,073.67	290.02	97.95	156.30	1,052.18
1994	7,109.43	619.49	2,758.25	526.93	167.29	213.27	110.38	1,176.72	1,470.80	1,096.49	299.85	102.88	161.52	1,092.55
1995	7,253.80	633.90	2,781.74	574.11	170.34	217.39	113.45	1,202.09	1,494.22	1,129.04	306.27	106.24	167.29	1,119.85

NOTE: Country gross domestic products were determined with 1993 purchasing power parities using the Elteto-Köves-Szulc (EKS) aggregation method, which is the method used by the Organisation for Economic Co-operation and Development (OECD) and EUROSTAT in their official statistics. For a discussion of the properties of this aggregation method, see OECD, *Purchasing Power Parities and Real Expenditures, 1993: Volume 1, EKS Results* (Paris: 1995), p. 4.

[a] German data are for the former West Germany only.

SOURCE: U.S. Bureau of Labor Statistics, Office of Productivity and Technology, "Comparative Real Gross Domestic Product Per Capita and Per Employed Person, Fourteen Countries, 1960-1995" (Washington, DC: April 1997).

See figure 6-1.

Appendix table 6-2.

Real gross domestic product per capita, for selected countries: 1960-95

(1995 U.S. dollars)

	United States	Canada	Japan	South Korea	Austria	Belgium	Denmark	France	Germany[a]	Italy	Netherlands	Norway	Sweden	United Kingdom
1960	13,460	9,542	4,460	1,444	7,806	8,338	9,598	8,290	9,825	7,053	8,745	8,170	9,406	9,685
1961	13,523	9,646	5,065	1,484	8,175	8,723	10,094	8,656	10,144	7,602	8,879	8,599	9,889	9,853
1962	14,120	10,139	5,371	1,473	8,320	9,141	10,571	9,070	10,494	8,007	9,132	8,760	10,253	9,893
1963	14,514	10,468	5,879	1,563	8,604	9,468	10,536	9,387	10,685	8,394	9,305	9,023	10,739	10,220
1964	15,150	10,958	6,587	1,670	9,063	10,032	11,389	9,897	11,282	8,542	9,971	9,404	11,386	10,703
1965	15,913	11,471	6,851	1,722	9,262	10,294	11,843	10,275	11,755	8,752	10,356	9,824	11,710	10,901
1966	16,745	12,024	7,507	1,883	9,716	10,549	12,021	10,721	11,975	9,206	10,508	10,113	11,842	11,048
1967	16,997	12,156	8,227	1,948	9,934	10,897	12,325	11,137	11,910	9,783	10,940	10,654	12,147	11,236
1968	17,623	12,610	9,172	2,120	10,324	11,310	12,741	11,530	12,515	10,347	11,555	10,801	12,515	11,640
1969	17,978	13,097	10,172	2,359	10,934	12,027	13,474	12,238	13,322	10,908	12,199	11,194	13,050	11,827
1970	17,772	13,250	11,019	2,510	11,672	12,786	13,647	12,823	13,858	11,402	12,743	11,339	13,769	12,060
1971	18,129	13,566	11,389	2,670	12,214	13,225	13,915	13,311	14,134	11,541	13,147	11,781	13,804	12,234
1972	18,911	14,178	12,181	2,747	12,897	13,871	14,564	13,780	14,642	11,795	13,417	12,295	14,078	12,624
1973	19,807	15,085	12,859	3,044	13,453	14,646	15,002	14,413	15,265	12,477	13,981	12,711	14,610	13,523
1974	19,555	15,532	12,529	3,234	13,960	15,200	14,795	14,764	15,275	12,940	14,434	13,289	15,034	13,290
1975	19,251	15,706	12,759	3,391	13,946	14,932	14,653	14,657	15,139	12,576	14,333	13,766	15,357	13,197
1976	20,131	16,456	13,119	3,730	14,610	15,739	15,562	15,218	16,022	13,319	14,892	14,635	15,464	13,566
1977	20,898	16,850	13,561	4,051	15,268	15,796	15,768	15,638	16,513	13,655	15,149	15,095	15,163	13,893
1978	21,714	17,445	14,147	4,365	15,289	16,215	15,951	16,092	17,028	14,118	15,414	15,721	15,383	14,376
1979	22,098	17,941	14,799	4,606	16,041	16,549	16,474	16,542	17,738	14,877	15,650	16,461	15,939	14,762
1980	21,786	17,973	15,096	4,413	16,509	17,245	16,382	16,725	17,852	15,387	15,711	17,098	16,173	14,419
1981	22,099	18,404	15,462	4,614	16,420	16,956	16,239	16,828	17,836	15,428	15,523	17,189	16,151	14,228
1982	21,419	17,598	15,827	4,888	16,580	17,231	16,740	17,158	17,681	15,437	15,273	17,183	16,304	14,483
1983	22,082	17,974	16,085	5,370	16,930	17,258	17,178	17,189	18,055	15,561	15,473	17,920	16,582	14,999
1984	23,383	18,925	16,609	5,765	17,152	17,636	17,939	17,334	18,638	15,928	15,921	18,896	17,238	15,313
1985	24,038	19,644	17,236	6,082	17,557	17,762	18,701	17,578	19,064	16,330	16,338	19,833	17,541	15,838
1986	24,538	20,092	17,627	6,718	17,742	18,045	19,356	17,936	19,497	16,771	16,697	20,588	17,902	16,468
1987	25,022	20,656	18,270	7,418	18,012	18,413	19,390	18,248	19,782	17,264	16,821	20,900	18,403	17,213
1988	25,737	21,407	19,319	8,174	18,700	19,221	19,604	18,969	20,394	17,900	17,148	20,683	18,731	18,027
1989	26,354	21,542	20,169	8,610	19,306	19,849	19,705	19,669	20,924	18,392	17,847	20,785	19,049	18,356
1990	26,420	21,174	21,122	9,336	19,943	20,520	19,954	20,051	21,702	18,757	18,455	21,101	19,160	18,364
1991	25,881	20,551	21,893	10,088	20,289	20,764	20,169	20,094	22,505	18,912	18,722	21,655	18,817	17,927
1992	26,299	20,403	22,053	10,490	20,440	21,030	20,148	20,215	22,623	18,994	18,958	22,235	18,441	17,771
1993	26,613	20,564	22,019	10,981	20,315	20,666	20,380	19,849	21,956	19,035	18,968	22,716	17,927	18,082
1994	27,273	21,175	22,073	11,804	20,834	21,083	21,201	20,323	22,333	19,393	19,495	23,724	18,394	18,710
1995	27,572	21,405	22,210	12,732	21,170	21,445	21,678	20,675	22,586	19,934	19,814	24,371	18,952	19,108

NOTE: Country gross domestic products were determined with 1993 purchasing power parities using the Elteto-Köves-Szulc (EKS) aggregation method, which is the method used by the Organisation for Economic Co-operation and Development (OECD) and EUROSTAT in their official statistics. For a discussion of the properties of this aggregation method, see OECD, *Purchasing Power Parities and Real Expenditures, 1993: Volume 1, EKS Results* (Paris: 1995), p. 4.

[a] German data are for the former West Germany only.

SOURCE: U.S. Bureau of Labor Statistics, Office of Productivity and Technology, "Comparative Real Gross Domestic Product Per Capita and Per Employed Person, Fourteen Countries, 1960-1995" (Washington, DC: April 1997).

See figure 6-1.

Science & Engineering Indicators – 1998

Appendix table 6-3.

Real gross domestic product per employed person, for selected countries: 1960-95

(1995 U.S. dollars)

	United States	Canada	Japan	South Korea	Austria	Belgium	Denmark	France	Germany[a]	Italy	Netherlands	Norway	Sweden	United Kingdom
1960	35,627	NA	9,545	NA	17,219	21,993	21,664	19,190	20,897	NA	21,801	19,090	19,461	21,030
1961	36,371	NA	10,791	NA	17,990	22,916	22,607	20,249	21,564	NA	22,111	19,940	20,401	21,350
1962	37,893	NA	11,421	NA	18,571	23,744	23,493	21,605	22,492	NA	22,609	20,362	21,155	21,527
1963	38,972	NA	12,514	5,562	19,458	24,604	23,315	22,579	23,069	NA	23,041	21,039	22,171	22,324
1964	40,361	NA	13,960	5,993	20,663	25,945	24,887	23,789	24,585	NA	24,590	22,023	23,348	23,235
1965	41,900	NA	14,452	6,022	21,393	26,766	25,613	24,849	25,755	NA	25,675	22,996	24,074	23,586
1966	43,307	NA	15,646	6,582	22,826	27,514	25,776	25,951	26,555	NA	26,190	23,761	24,543	23,975
1967	43,411	NA	16,981	6,735	23,931	28,706	26,826	27,098	27,365	NA	27,664	25,074	25,643	24,810
1968	44,526	NA	18,793	7,140	25,329	29,945	27,582	28,337	28,833	NA	29,246	25,608	26,297	25,946
1969	44,771	NA	20,895	7,905	26,936	31,398	29,065	29,862	30,509	NA	30,723	26,530	27,104	26,481
1970	44,523	NA	22,685	8,305	28,743	33,368	29,445	31,151	31,645	NA	32,109	26,631	28,305	27,162
1971	45,816	NA	23,526	8,723	29,864	34,351	30,057	32,494	32,481	NA	33,339	27,597	28,628	28,111
1972	46,925	NA	25,451	8,717	31,495	36,243	30,993	33,735	33,727	NA	34,675	28,712	29,187	28,917
1973	48,037	NA	26,799	9,320	32,477	38,057	31,718	35,084	34,953	NA	36,410	29,696	30,232	30,449
1974	46,986	NA	26,567	9,684	33,474	39,020	31,527	35,863	35,451	NA	37,521	30,836	30,592	29,860
1975	47,236	NA	27,484	10,114	33,551	39,003	31,720	36,077	35,973	NA	37,869	31,512	30,766	29,799
1976	48,300	39,289	28,308	10,650	34,881	41,409	33,178	37,315	38,090	NA	39,445	32,572	30,985	30,875
1977	48,896	39,891	29,161	11,409	36,136	41,774	33,443	38,198	39,118	NA	39,529	32,896	30,429	31,566
1978	49,245	40,339	30,326	11,962	36,074	42,871	33,584	39,284	39,965	NA	40,084	33,784	30,846	32,395
1979	49,294	40,199	31,594	12,652	37,562	43,389	34,360	40,481	40,967	NA	40,226	34,956	31,571	32,879
1980	48,926	39,625	32,153	12,295	38,535	45,308	34,369	41,070	40,737	NA	39,482	35,621	31,746	32,503
1981	49,570	39,945	32,896	12,741	38,406	45,422	34,517	41,755	40,821	41,076	39,073	35,587	31,690	33,227
1982	48,905	39,920	33,562	13,369	39,318	46,785	35,400	42,701	40,925	41,401	38,824	35,651	32,069	34,155
1983	50,221	40,918	33,779	14,776	40,479	47,337	36,184	43,058	42,246	41,826	40,275	37,437	32,556	35,575
1984	51,551	42,381	34,905	16,143	41,049	48,468	37,131	44,011	43,365	42,732	41,079	39,346	33,594	35,814
1985	52,415	43,116	36,195	16,578	41,956	48,557	37,778	44,973	43,918	43,810	41,165	40,339	33,893	36,688
1986	52,806	43,254	36,935	17,856	42,272	49,011	38,154	45,924	44,334	44,835	41,647	40,779	34,457	38,027
1987	52,978	43,870	38,090	18,879	42,991	49,805	37,938	46,807	44,666	46,373	41,525	40,752	35,260	38,970
1988	53,819	44,640	39,777	20,366	44,473	51,509	38,609	48,481	45,971	48,048	42,540	40,853	35,565	39,554
1989	54,534	44,801	40,882	20,813	45,499	52,463	39,044	49,885	46,953	49,472	43,578	42,420	35,887	39,492
1990	54,595	44,433	42,121	22,131	46,530	53,624	40,002	50,611	48,201	49,955	43,509	43,569	36,043	39,368
1991	54,571	44,475	42,955	23,468	47,103	54,396	41,154	50,951	49,402	50,176	43,738	45,272	36,183	39,508
1992	55,767	45,079	42,931	24,203	47,849	55,563	41,510	51,921	49,819	50,897	43,281	46,888	37,330	39,939
1993	56,279	45,475	42,859	25,206	48,289	55,409	42,541	51,832	49,603	51,592	43,157	48,093	38,516	41,085
1994	56,978	46,345	43,030	26,563	49,693	57,106	44,664	53,335	51,310	53,587	44,554	49,930	40,209	42,298
1995	57,333	46,693	43,377	28,174	50,746	57,977	45,166	53,843	52,462	55,841	44,776	50,511	41,013	43,137

NA = not available

NOTE: Country gross domestic products were determined with 1993 purchasing power parities using the Elteto-Köves-Szulc (EKS) aggregation method, which is the method used by the Organisation for Economic Co-operation and Development (OECD) and EUROSTAT in their official statistics. For a discussion of the properties of this aggregation method, see OECD, *Purchasing Power Parities and Real Expenditures, 1993: Volume 1, EKS Results* (Paris: 1995), p. 4.

[a] German data are for the former West Germany only.

SOURCE: U.S. Bureau of Labor Statistics, Office of Productivity and Technology, "Comparative Real Gross Domestic Product Per Capita and Per Employed Person, Fourteen Countries, 1960-1995" (Washington, DC: April 1997).

See figure 6-1.

Appendix table 6-4.

High-technology manufacturing in selected industrialized countries, value added and domestic content: 1970-95

	Total manufacturing		Aircraft		Communications		Office & computers		Drugs & medicines		High-tech manufacturing		Other manufacturing	
	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]
							United States							
1970	249,584.0	39.9	NA	NA	6,664.1	46.3	3,233.6	44.0	3,425.6	51.6	NA	NA	NA	NA
1971	263,018.0	40.0	10,495.9	NA	6,992.5	47.8	3,072.0	48.3	3,795.8	53.3	24,356.2	86.7	NA	NA
1972	290,424.0	38.9	11,234.4	47.9	7,528.8	45.6	3,620.5	45.5	4,465.2	56.9	26,848.9	48.1	263,575.1	38.2
1973	323,403.0	37.4	12,165.5	42.1	8,796.2	44.3	4,022.8	44.5	4,736.4	54.2	29,721.0	44.7	293,682.0	36.8
1974	337,278.0	33.3	12,819.4	42.6	7,062.3	35.2	4,451.3	45.6	4,668.2	46.8	29,001.3	41.5	308,276.8	32.7
1975	354,689.0	34.8	13,172.8	41.3	8,791.1	43.7	4,827.9	55.9	5,408.9	49.5	32,200.7	45.0	322,488.3	34.1
1976	405,313.0	34.7	14,018.4	44.0	9,900.5	42.9	5,536.7	43.3	6,408.5	50.4	35,864.0	44.6	369,449.0	34.0
1977	462,365.0	34.5	15,814.7	47.0	12,683.5	43.4	6,661.2	40.4	6,728.6	47.7	41,888.0	44.8	420,477.0	33.8
1978	516,936.0	34.4	18,499.0	45.1	14,580.6	42.6	8,246.0	40.9	7,427.8	46.2	48,753.4	43.7	468,182.6	33.6
1979	571,281.0	33.5	20,217.6	37.7	15,332.4	38.4	9,853.0	38.3	8,099.3	48.1	53,502.2	39.3	517,778.8	33.0
1980	584,406.0	32.1	20,083.8	32.8	19,821.6	41.8	11,959.5	38.4	9,352.2	48.1	61,217.1	38.4	523,188.9	31.5
1981	652,014.0	32.7	30,723.8	46.1	23,437.1	44.2	13,745.7	39.1	10,958.3	50.3	78,864.9	44.6	573,149.1	31.6
1982	649,768.0	33.7	33,401.5	46.8	24,414.1	43.2	15,330.3	37.4	12,911.4	53.2	86,057.3	44.6	563,710.7	32.5
1983	690,088.0	33.8	37,898.5	49.4	29,013.1	45.0	17,314.5	37.7	14,703.9	54.2	98,930.0	46.1	591,158.0	32.3
1984	780,524.0	34.3	39,989.5	46.1	36,191.5	43.3	19,856.0	35.1	15,304.0	53.2	111,341.0	43.6	669,183.0	33.2
1985	802,938.0	35.0	43,277.1	45.2	40,016.8	44.5	20,101.8	35.4	17,315.7	55.7	120,711.4	44.1	682,226.6	33.8
1986	833,149.0	36.4	48,064.1	46.4	41,814.8	44.2	18,079.4	34.8	18,691.8	54.1	126,650.1	44.5	706,498.9	35.3
1987	889,047.0	36.4	47,786.5	43.4	48,234.5	51.9	17,187.1	32.5	20,683.6	54.3	133,891.7	45.6	755,155.3	35.1
1988	971,297.0	36.5	49,504.9	43.5	51,642.7	51.6	18,864.1	31.4	23,209.5	54.1	143,221.2	45.2	828,075.8	35.3
1989	1,013,420.0	36.0	51,646.4	43.6	56,792.5	54.1	19,512.1	32.5	25,769.1	53.1	153,720.1	46.3	859,699.9	34.6
1990	1,031,350.0	35.8	53,608.2	41.0	57,367.3	52.6	19,299.1	33.2	29,075.2	55.0	159,349.8	45.4	872,000.2	34.5
1991	1,028,060.0	36.2	47,616.7	36.3	60,357.8	53.1	16,819.8	31.3	33,416.9	55.5	158,211.2	44.1	869,848.8	35.1
1992	1,063,570.0	35.9	45,246.7	35.4	62,524.0	49.2	17,618.3	29.6	36,165.7	55.2	161,554.7	42.5	902,015.3	34.9
1993	1,116,530.0	36.1	39,487.0	32.6	70,890.2	51.1	17,458.4	27.9	38,624.2	56.4	166,459.8	42.6	950,070.2	35.1
1994	1,197,090.0	36.2	NA	NA	84,507.9	53.9	19,521.9	27.3	40,586.0	55.0	NA	NA	NA	NA
1995	1,287,710.0	36.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

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Appendix table 6-4.

High-technology manufacturing in selected industrialized countries, value added and domestic content: 1970-95

	Total manufacturing		Aircraft		Communications		Office & computers		Drugs & medicines		High-tech manufacturing		Other manufacturing	
	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]
							Japan							
1970	26,402,200.0	32.8	44,334.4	44.3	1,470,640.0	37.5	312,745.0	36.2	549,674.0	55.8	2,377,393.4	40.5	24,024,806.6	32.2
1971	28,430,200.0	33.8	51,899.5	45.3	1,458,200.0	37.7	327,933.0	38.1	658,130.0	60.0	2,496,162.5	42.0	25,934,037.5	33.1
1972	31,917,900.0	34.3	62,418.6	45.3	1,738,620.0	39.1	365,772.0	39.5	672,480.0	61.4	2,839,290.6	43.0	29,078,609.4	33.7
1973	39,568,100.0	33.5	90,705.1	47.1	1,972,330.0	37.5	449,269.0	35.6	704,728.0	58.7	3,217,032.1	40.6	36,351,067.9	32.9
1974	45,137,200.0	30.8	108,524.0	48.5	2,078,780.0	37.0	581,084.0	36.1	619,336.0	42.4	3,387,724.0	38.0	41,749,476.0	30.3
1975	44,800,800.0	31.0	121,152.0	49.0	1,972,680.0	38.4	556,282.0	36.9	856,016.0	51.6	3,506,130.0	41.0	41,294,670.0	30.4
1976	51,100,500.0	30.9	133,580.0	49.5	2,618,840.0	36.0	600,145.0	39.2	995,602.0	55.0	4,348,167.0	39.9	46,752,333.0	30.2
1977	55,412,200.0	31.2	132,919.0	49.0	2,822,760.0	36.4	726,608.0	33.5	1,178,250.0	57.9	4,860,537.0	39.7	50,551,663.0	30.6
1978	60,545,300.0	32.6	148,533.0	49.0	2,928,110.0	36.2	836,794.0	33.5	1,502,180.0	67.5	5,415,617.0	41.3	55,129,683.0	32.0
1979	64,815,400.0	31.2	134,096.0	42.8	3,240,990.0	35.4	989,708.0	33.7	1,312,850.0	55.6	5,677,644.0	38.4	59,137,756.0	30.7
1980	70,232,300.0	29.0	153,506.0	44.4	3,932,900.0	33.2	1,179,570.0	33.5	1,476,360.0	52.4	6,742,336.0	36.4	63,489,964.0	28.3
1981	74,938,500.0	29.9	147,224.0	44.6	4,865,830.0	33.3	1,335,990.0	32.4	1,760,620.0	55.5	8,109,664.0	36.5	66,828,836.0	29.2
1982	78,467,500.0	30.9	176,235.0	42.7	5,393,120.0	35.3	1,542,630.0	34.0	1,928,100.0	55.9	9,040,085.0	38.2	69,427,415.0	30.1
1983	81,747,700.0	31.5	203,000.0	43.8	6,278,730.0	34.8	1,986,090.0	34.3	2,093,640.0	58.0	10,561,460.0	37.9	71,186,240.0	30.7
1984	89,244,900.0	31.9	231,453.0	45.0	8,146,470.0	34.7	2,342,440.0	32.7	2,046,000.0	57.0	12,766,363.0	36.7	76,478,537.0	31.2
1985	94,672,600.0	32.9	283,397.0	45.1	8,276,160.0	35.3	2,853,440.0	35.6	2,107,600.0	57.8	13,520,597.0	37.8	81,152,003.0	32.2
1986	95,817,400.0	35.0	265,439.0	44.0	8,308,320.0	35.3	2,912,310.0	36.6	2,326,180.0	61.7	13,812,249.0	38.5	82,005,151.0	34.4
1987	98,406,700.0	36.2	331,277.0	47.6	8,285,500.0	35.6	2,895,760.0	34.6	2,478,640.0	61.7	13,991,177.0	38.5	84,415,523.0	35.8
1988	105,000,000.0	35.9	297,266.0	41.4	9,291,270.0	35.2	3,117,800.0	34.6	2,526,560.0	60.1	15,232,896.0	37.8	89,767,104.0	35.6
1989	113,000,000.0	35.7	265,123.0	36.2	10,281,900.0	36.0	3,535,620.0	34.9	2,756,460.0	61.2	16,839,103.0	38.4	96,160,897.0	35.3
1990	121,000,000.0	35.6	262,173.0	35.1	10,973,200.0	36.3	3,946,330.0	35.0	2,778,640.0	60.3	17,960,343.0	38.3	103,039,657.0	35.2
1991	129,000,000.0	36.1	276,712.0	37.0	11,580,100.0	35.7	4,218,600.0	34.4	2,864,740.0	60.7	18,940,152.0	37.8	110,059,848.0	35.8
1992	128,000,000.0	37.1	316,265.0	38.9	10,349,400.0	35.5	4,007,420.0	33.7	2,992,610.0	61.4	17,665,695.0	37.8	110,334,305.0	37.0
1993	121,000,000.0	37.1	350,262.0	41.7	9,763,680.0	34.8	3,430,760.0	31.7	3,098,270.0	61.8	16,642,972.0	37.2	104,357,028.0	37.1
1994	117,000,000.0	37.2	NA	NA	9,629,530.0	35.5	3,189,820.0	34.2	3,115,700.0	NA	NA	NA	NA	NA
1995	120,000,000.0	37.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Appendix table 6-4.

High-technology manufacturing in selected industrialized countries, value added and domestic content: 1970-95

	Total manufacturing		Aircraft		Communications		Office & computers		Drugs & medicines		High-tech manufacturing		Other manufacturing	
	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]
Germany														
1970	259,450.0	40.0	934.6	33.7	NA	NA	4,018.1	79.7	NA	NA	NA	NA	NA	NA
1971	277,210.0	40.2	1,011.1	33.5	NA	NA	4,383.3	80.0	NA	NA	NA	NA	NA	NA
1972	295,650.0	40.4	1,159.2	37.5	NA	NA	5,033.5	80.6	NA	NA	NA	NA	NA	NA
1973	332,580.0	40.2	1,651.3	42.9	NA	NA	5,238.3	81.0	NA	NA	NA	NA	NA	NA
1974	354,320.0	38.0	1,647.1	38.9	NA	NA	5,311.6	79.6	NA	NA	NA	NA	NA	NA
1975	352,540.0	38.0	1,528.7	39.8	NA	NA	4,551.5	82.5	5,501.4	48.7	NA	NA	NA	NA
1976	387,270.0	37.4	1,744.7	45.8	21,028.0	50.0	4,934.4	83.1	6,050.4	47.9	33,757.5	52.4	353,512.5	36.4
1977	411,480.0	38.2	1,764.5	46.4	22,689.3	56.3	5,930.0	81.8	6,444.5	46.7	36,828.3	56.5	374,651.7	37.0
1978	435,350.0	38.9	2,491.1	55.0	22,894.1	56.4	5,951.5	81.6	6,993.3	50.4	38,330.1	57.8	397,019.9	37.7
1979	467,080.0	37.7	2,928.2	48.9	23,919.8	54.5	6,130.5	81.4	7,466.1	50.6	40,444.6	56.0	426,635.4	36.5
1980	476,250.0	35.8	3,272.1	38.1	25,281.6	54.0	6,236.4	77.8	7,356.0	47.1	42,146.1	53.3	434,103.9	34.7
1981	485,710.0	35.0	3,894.3	39.7	26,710.0	54.2	7,582.4	75.6	8,257.4	49.3	46,444.0	54.1	439,266.0	33.8
1982	496,010.0	35.2	3,938.0	34.2	29,017.4	54.6	8,595.1	81.5	8,579.9	50.5	50,130.4	54.4	445,879.6	33.9
1983	519,420.0	35.9	3,932.2	39.0	30,586.4	53.3	9,645.1	76.4	9,676.3	51.5	53,840.0	54.5	465,580.0	34.5
1984	542,600.0	35.2	4,261.0	42.4	31,774.7	52.2	10,732.0	63.7	9,902.6	49.2	56,670.3	52.5	485,929.7	33.9
1985	578,850.0	35.3	4,390.4	40.9	35,119.6	50.4	11,645.3	59.0	10,367.3	49.9	61,522.6	50.9	517,327.4	34.1
1986	620,440.0	38.0	4,716.0	44.5	37,748.9	49.7	12,199.6	62.4	11,770.7	53.3	66,435.2	51.8	554,004.8	36.8
1987	624,690.0	38.1	5,005.4	41.4	40,639.2	55.8	11,786.0	63.9	11,267.4	49.8	68,698.0	54.5	555,992.0	36.8
1988	652,670.0	37.7	5,534.7	45.9	43,421.3	57.2	12,208.3	63.3	12,339.5	50.3	73,503.8	55.8	579,166.2	36.2
1989	686,010.0	36.6	6,254.1	37.7	46,078.2	56.5	11,959.0	63.6	12,793.0	48.0	77,084.3	53.7	608,925.7	35.2
1990	741,550.0	37.0	6,751.8	36.3	48,472.8	54.1	12,635.2	61.0	13,462.0	47.1	81,321.8	51.6	660,228.2	35.7
1991	790,660.0	36.8	7,648.6	38.7	48,115.2	48.6	16,935.1	58.9	14,714.5	49.9	87,413.4	49.4	703,246.6	35.6
1992	799,090.0	37.1	7,585.2	42.7	48,153.7	48.0	14,677.4	55.4	15,746.1	49.7	86,162.4	48.9	712,927.6	36.0
1993	746,310.0	37.2	NA	NA	45,918.9	46.4	11,288.3	52.4	16,032.3	51.3	NA	NA	NA	NA
1994	765,980.0	36.9	NA	NA	46,476.6	45.8	12,332.2	49.4	16,747.5	51.0	NA	NA	NA	NA
1995	789,452.0	36.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

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Appendix table 6-4.

High-technology manufacturing in selected industrialized countries, value added and domestic content: 1970-95

	Total manufacturing		Aircraft		Communications		Office & computers		Drugs & medicines		High-tech manufacturing		Other manufacturing	
	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]
							France							
1970	215,840.0	38.5	3,042.1	35.8	6,646.6	52.6	4,787.8	61.4	2,449.5	30.8	16,925.9	45.9	198,914.1	38.0
1971	238,979.0	38.7	3,373.1	36.0	7,610.5	52.3	4,958.0	59.9	2,828.0	30.9	18,769.6	45.4	220,209.4	38.3
1972	265,734.0	38.8	3,861.5	36.8	8,710.6	50.7	5,288.2	59.3	2,995.6	30.6	20,855.9	45.0	244,878.1	38.4
1973	302,922.0	38.2	4,261.5	35.6	10,425.4	50.0	4,959.0	55.4	3,491.6	31.1	23,137.5	43.7	279,784.5	37.8
1974	342,318.0	34.5	4,491.6	31.2	12,618.0	49.6	5,255.1	55.6	4,085.3	31.3	26,450.0	42.4	315,868.0	33.9
1975	381,286.0	37.4	6,030.2	36.3	14,605.9	49.4	5,772.4	53.6	4,753.1	31.0	31,161.6	43.1	350,124.4	36.9
1976	440,749.0	37.0	9,302.5	38.6	16,866.2	48.3	7,429.9	54.1	5,197.5	31.1	38,796.2	43.4	401,952.9	36.4
1977	496,403.0	37.5	10,401.0	39.1	19,146.8	47.4	8,815.8	54.1	5,831.0	31.2	44,194.6	43.3	452,208.4	37.0
1978	564,275.0	39.1	12,980.0	45.8	21,402.6	46.7	8,825.8	53.3	7,558.0	33.3	50,766.4	44.8	513,508.6	38.6
1979	635,601.0	38.1	13,802.0	42.0	25,020.7	43.2	9,718.4	51.3	8,308.0	34.4	56,849.1	42.5	578,751.9	37.7
1980	679,520.0	35.6	16,032.0	39.5	27,054.3	43.9	11,041.2	51.1	9,857.0	34.4	63,984.5	42.0	615,535.5	35.0
1981	733,461.0	34.8	20,108.0	37.9	30,620.0	45.3	13,287.8	50.6	11,377.0	33.3	75,392.8	41.6	658,068.2	34.1
1982	821,520.0	35.0	22,480.0	37.0	34,829.1	45.0	15,791.5	48.4	12,526.0	32.3	85,626.6	40.8	735,893.4	34.4
1983	900,970.0	35.6	27,250.0	40.8	39,133.7	43.2	18,105.4	45.2	15,256.0	34.2	99,745.1	41.2	801,224.9	35.0
1984	956,273.0	34.6	29,913.0	36.9	46,728.4	42.9	25,249.8	48.3	15,271.0	31.2	117,162.2	40.2	839,110.8	33.9
1985	1,033,130.0	35.3	31,005.0	38.1	49,149.9	41.0	28,660.3	47.6	16,247.9	30.0	125,063.1	39.6	908,066.9	34.8
1986	1,120,100.0	38.4	31,444.0	38.6	50,915.5	40.3	29,114.3	47.9	18,851.0	32.1	130,324.8	39.8	989,775.2	38.2
1987	1,143,220.0	38.1	30,661.0	36.8	54,579.1	40.5	27,852.4	47.3	20,368.0	33.3	133,460.5	39.5	1,009,759.5	37.9
1988	1,242,130.0	38.3	35,566.0	37.3	59,239.2	40.9	31,247.6	45.8	21,645.9	31.5	147,698.7	39.2	1,094,431.3	38.2
1989	1,324,620.0	37.3	38,809.0	35.0	62,245.9	39.4	33,131.6	43.6	21,884.0	29.1	156,070.5	37.2	1,168,549.5	37.3
1990	1,394,500.0	37.7	39,840.0	32.5	64,615.6	38.9	34,470.6	44.1	24,548.9	30.5	163,475.1	36.5	1,231,024.9	37.9
1991	1,409,770.0	37.7	39,877.0	32.0	66,026.1	37.4	34,360.4	42.7	25,742.9	30.4	166,006.4	35.6	1,243,763.6	38.0
1992	1,402,730.0	37.6	39,883.0	31.4	66,815.0	37.7	32,387.0	41.8	29,427.9	31.9	168,512.9	35.5	1,234,217.1	37.9
1993	1,380,290.0	38.7	40,646.0	33.6	66,032.0	38.2	28,850.0	40.6	32,935.8	33.9	168,463.8	36.5	1,211,826.2	39.0
1994	1,423,060.0	37.9	38,330.0	31.4	67,573.0	37.4	28,584.0	39.1	31,715.8	32.2	166,202.8	35.0	1,256,857.2	38.3
1995	1,478,010.0	37.6	42,874.0	34.7	71,080.0	37.2	29,687.0	38.0	32,670.0	31.2	176,311.0	35.4	1,301,699.0	37.9

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Appendix table 6-4.

High-technology manufacturing in selected industrialized countries, value added and domestic content: 1970-95

	Total manufacturing		Aircraft		Communications		Office & computers		Drugs & medicines		High-tech manufacturing		Other manufacturing	
	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]
United Kingdom														
1970	14,839.0	31.3	474.6	78.5	546.5	36.9	117.6	32.3	226.3	42.5	1,365.1	45.7	13,473.9	30.4
1971	16,093.0	32.0	534.0	81.1	638.1	38.1	115.7	34.2	259.8	44.8	1,547.5	47.6	14,545.5	30.9
1972	18,088.0	33.6	577.7	82.6	717.2	39.1	161.9	38.9	259.8	44.0	1,716.6	48.5	16,371.4	32.6
1973	20,969.0	33.1	606.0	79.8	840.9	37.8	181.8	35.8	292.1	41.0	1,920.8	45.7	19,048.2	32.2
1974	22,720.0	27.3	563.5	64.0	919.4	35.4	216.3	33.3	316.3	35.6	2,015.6	40.2	20,704.4	26.5
1975	27,657.0	29.7	764.3	69.2	1,136.4	39.7	301.0	39.6	412.2	39.3	2,614.0	45.3	25,043.0	28.7
1976	31,883.0	28.2	842.4	38.5	1,223.2	35.4	271.1	30.9	474.0	37.6	2,810.7	36.1	29,072.3	27.6
1977	38,512.0	29.2	896.4	38.6	1,483.2	38.2	352.1	35.9	669.5	41.6	3,401.1	38.7	35,110.9	28.5
1978	44,586.0	31.2	1,046.4	39.8	1,805.7	40.4	433.7	38.4	808.6	43.2	4.094.3	40.6	40,491.7	30.5
1979	49,395.0	29.9	1,159.5	35.5	1,906.6	38.0	570.5	38.4	921.2	41.0	4,557.8	37.9	44,837.2	29.2
1980	54,144.0	30.7	1,727.3	37.1	2,407.2	40.4	642.0	40.5	1,107.7	45.4	5,884.2	40.2	48,259.8	29.8
1981	55,834.0	31.3	1,861.6	35.1	2,578.7	39.9	621.1	42.5	1,192.1	45.2	6,253.5	39.4	49,580.5	30.5
1982	61,158.0	32.3	2,004.2	37.7	3,051.5	42.5	771.6	44.4	1,493.2	49.0	7,320.4	42.4	53,837.6	31.3
1983	64,738.0	31.8	2,305.5	41.0	3,296.0	40.2	921.1	40.0	1,553.8	47.5	8,076.4	41.6	56,661.6	30.7
1984	68,634.0	30.3	2,139.2	36.8	3,890.0	38.6	1,111.6	33.9	1,725.8	47.0	8,866.6	38.8	59,767.4	29.4
1985	76,801.0	31.7	2,228.8	33.1	4,222.1	40.0	1,509.1	35.1	1,988.4	49.3	9,948.3	38.8	66,852.7	30.8
1986	82,422.0	34.1	2,942.0	36.2	4,285.4	39.7	1,499.9	36.5	2,182.4	49.3	10,909.7	39.7	71,512.3	33.4
1987	89,902.0	33.1	3,028.1	34.1	4,459.8	38.5	1,791.9	34.7	2,526.0	50.3	11,805.7	38.5	78,096.3	32.5
1988	100,232.0	33.5	3,394.6	37.2	4,972.2	39.1	2,302.6	34.0	2,939.6	51.4	13,609.0	39.6	86,623.1	32.8
1989	107,166.0	32.9	4,200.7	38.6	4,867.5	35.8	2,398.2	30.6	3,175.9	50.0	14,642.2	37.9	92,523.8	32.2
1990	111,315.0	32.9	5,078.3	42.7	4,914.4	35.2	2,465.8	29.7	3,493.2	51.1	15,951.6	38.9	95,363.4	32.0
1991	106,896.0	32.6	4,770.9	39.6	4,744.9	36.2	2,331.7	28.1	3,801.1	50.5	15,648.6	38.2	91,247.5	31.8
1992	109,071.0	32.2	3,818.5	28.9	4,790.2	36.2	2,093.1	24.0	4,216.0	48.7	14,917.8	34.0	94,153.2	31.9
1993	113,940.0	32.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1994	121,272.0	32.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1995	128,631.0	32.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

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Appendix table 6-4.
High-technology manufacturing in selected industrialized countries, value added and domestic content: 1970-95

	Total manufacturing		Aircraft		Communications		Office & computers		Drugs & medicines		High-tech manufacturing		Other manufacturing	
	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]
							Italy							
1970	18,105,000.0	36.4	92,206.4	30.8	455,451.0	47.3	415,480.0	56.5	358,597.0	32.5	1,321,734.4	42.6	16,783,265.6	36.0
1971	19,452,000.0	36.4	110,424.0	30.4	518,762.0	48.5	369,564.0	59.7	386,415.0	32.8	1,385,165.0	42.9	18,066,835.0	36.0
1972	21,016,000.0	36.5	116,961.0	30.1	572,976.0	48.4	282,613.0	61.4	402,055.0	32.4	1,374,605.0	42.0	19,641,395.0	36.1
1973	26,064,000.0	36.6	115,832.0	28.2	660,403.0	50.7	227,590.0	66.2	420,390.0	34.9	1,424,215.0	43.7	24,639,785.0	36.2
1974	34,901,000.0	36.5	148,263.0	30.0	846,521.0	49.9	275,660.0	67.1	502,252.0	43.9	1,772,696.0	47.3	33,128,304.0	36.1
1975	38,436,000.0	36.6	205,515.0	27.1	920,971.0	46.5	312,219.0	64.4	606,728.0	41.4	2,045,433.0	43.6	36,390,567.0	36.2
1976	51,506,000.0	36.6	325,492.0	27.9	1,269,360.0	42.5	411,565.0	60.7	769,069.0	42.3	2,775,486.0	41.7	48,730,514.0	36.3
1977	61,862,000.0	36.6	407,608.0	29.5	1,583,880.0	39.6	488,671.0	58.2	839,007.0	41.3	3,319,166.0	40.2	58,542,834.0	36.4
1978	71,459,000.0	36.6	495,955.0	26.1	1,626,920.0	37.5	541,710.0	56.8	986,175.0	41.9	3,650,760.0	38.2	67,808,240.0	36.5
1979	87,935,000.0	36.6	626,340.0	27.5	1,916,120.0	37.8	772,625.0	58.3	1,191,210.0	42.2	4,506,295.0	39.2	83,428,705.0	36.5
1980	107,923,000.0	36.6	797,661.0	25.6	2,152,840.0	35.7	960,427.0	57.3	1,655,330.0	46.0	5,566,258.0	38.6	102,356,742.0	36.5
1981	124,119,000.0	36.0	1,191,630.0	25.7	2,617,300.0	37.7	1,174,270.0	55.1	1,825,950.0	44.8	6,809,150.0	38.3	117,309,850.0	35.9
1982	140,932,000.0	35.6	1,448,060.0	24.0	3,175,750.0	34.8	1,451;200.0	53.7	2,292,240.0	43.2	8,367,250.0	36.1	132,564,750.0	35.6
1983	156,417,000.0	35.6	1,574,680.0	31.2	4,114,330.0	51.9	1,685,190.0	62.5	3,600,430.0	61.4	10,974,630.0	51.0	145,442,370.0	34.8
1984	176,942,000.0	34.2	1,707,630.0	36.4	4,602,440.0	54.2	2,047,180.0	59.3	3,977,200.0	54.9	12,334,450.0	51.7	164,607,550.0	33.4
1985	196,484,000.0	34.2	1,864,080.0	26.8	4,901,630.0	41.9	2,732,170.0	76.4	4,745,400.0	50.2	14,243,280.0	45.0	182,240,720.0	33.5
1986	213,686,000.0	35.9	2,247,060.0	36.5	5,306,900.0	45.0	2,751,730.0	30.9	4,986,940.0	48.5	15,292,630.0	41.2	198,393,370.0	35.6
1987	230,093,000.0	35.8	2,321,930.0	40.3	5,816,800.0	46.4	2,914,680.0	31.5	5,598,060.0	43.0	16,651,470.0	41.1	213,441,530.0	35.4
1988	256,378,000.0	34.8	2,567,880.0	35.9	6,619,280.0	40.0	3,106,570.0	24.7	NA	NA	NA	NA	NA	NA
1989	279,654,000.0	33.8	3,273,600.0	45.2	7,884,310.0	49.3	3,308,120.0	31.2	NA	NA	NA	NA	NA	NA
1990	293,622,000.0	34.3	3,544,500.0	46.5	8,608,650.0	51.1	2,886,320.0	24.9	NA	NA	NA	NA	NA	NA
1991	300,246,000.0	34.9	3,285,340.0	45.9	8,860,790.0	52.5	2,904,940.0	30.3	NA	NA	NA	NA	NA	NA
1992	307,906,000.0	35.5	NA	NA	8,883,320.0	54.2	3,167,660.0	32.5	NA	NA	NA	NA	NA	NA
1993	310,429,000.0	35.3	NA	NA	8,520,540.0	53.5	3,085,930.0	33.1	NA	NA	NA	NA	NA	NA
1994	331,620,000.0	34.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1995	369,033,000.0	33.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

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Appendix table 6-4.

High-technology manufacturing in selected industrialized countries, value added and domestic content: 1970-95

	Total manufacturing		Aircraft		Communications		Office & computers		Drugs & medicines		High-tech manufacturing		Other manufacturing	
	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]
South Korea														
1970	581,700.0	25.8	NA	NA	16,885.7	40.7	312,745.0	36.2	11,706.0	39.2	341,336.7	36.5	240,363.3	18.2
1971	721,900.0	24.7	NA	NA	25,898.1	39.5	327,933.0	38.1	16,206.0	40.6	370,037.1	38.3	351,862.9	18.0
1972	937,000.0	25.0	NA	NA	39,020.8	33.7	365,772.0	39.5	17,120.5	36.4	421,913.3	38.8	515,086.7	19.4
1973	1,350,200.0	25.0	NA	NA	76,210.2	30.5	449,269.0	35.6	20,159.1	35.0	545,638.3	34.8	804,561.7	21.0
1974	1,970,300.0	23.2	NA	NA	154,792.0	34.0	581,084.0	36.1	34,424.8	40.4	770,300.8	35.9	1,199,999.2	19.0
1975	2,665,300.0	24.1	NA	NA	202,702.0	36.8	556,282.0	36.9	58,688.5	36.7	817,672.5	36.9	1,847,627.5	20.9
1976	3,862,400.0	25.3	NA	NA	307,050.0	32.8	600,145.0	39.2	84,443.9	43.2	991,638.9	37.2	2,870,761.1	22.7
1977	4,837,300.0	25.3	NA	NA	327,563.0	32.2	726,608.0	33.5	112,835.0	44.7	1,167,006.0	34.0	3,670,294.0	23.4
1978	6,513,900.0	25.3	NA	NA	436,609.0	28.4	836,794.0	33.5	148,212.0	45.2	1,421,615.0	32.6	5,092,285.0	23.9
1979	8,644,800.0	24.6	NA	NA	608,218.0	29.0	989,708.0	33.7	176,438.0	40.3	1,774,364.0	32.4	6,870,436.0	23.2
1980	10,743,100.0	22.8	NA	NA	700,517.0	29.7	1,179,570.0	33.5	266,539.0	43.4	2,146,626.0	33.0	8,596,474.0	21.2
1981	13,566,700.0	22.8	NA	NA	921,156.0	29.8	1,335,990.0	32.4	290,042.0	41.8	2,547,188.0	32.2	11,019,512.0	21.4
1982	15,376,400.0	23.2	NA	NA	974,522.0	29.8	1,542,630.0	34.0	380,122.0	44.7	2,897,274.0	33.5	12,479,126.0	21.7
1983	18,637,000.0	24.3	NA	NA	1,358,180.0	30.2	1,986,090.0	34.3	456,738.0	46.9	3,801,008.0	33.7	14,835,992.0	22.6
1984	21,989,100.0	24.6	NA	NA	1,890,080.0	30.9	2,342,440.0	32.7	517,734.0	45.7	4,750,254.0	32.9	17,238,846.0	23.0
1985	24,080,000.0	24.8	NA	NA	1,958,250.0	30.9	2,853,440.0	35.6	558,327.0	45.0	5,370,017.0	34.4	18,709,983.0	23.0
1986	29,449,400.0	25.5	NA	NA	2,722,600.0	28.1	2,912,310.0	36.6	681,001.0	50.1	6,315,911.0	33.2	23,133,489.0	24.0
1987	35,173,500.0	25.1	NA	NA	3,471,710.0	25.2	2,895,760.0	34.6	734,021.0	50.6	7,101,491.0	30.1	28,072,009.0	24.0
1988	42,679,200.0	26.3	NA	NA	4,395,730.0	26.1	3,117,800.0	34.6	989,079.0	46.5	8,502,609.0	30.4	34,176,591.0	25.4
1989	46,252,900.0	26.6	NA	NA	4,896,630.0	28.8	3,535,620.0	34.9	931,269.0	49.9	9,363,519.0	32.3	36,889,381.0	25.5
1990	52,351,000.0	26.5	NA	NA	5,855,520.0	30.8	3,946,330.0	35.0	923,660.0	38.7	10,725,510.0	32.8	41,625,490.0	25.3
1991	61,527,300.0	27.5	NA	NA	6,687,980.0	32.1	4,218,600.0	34.4	1,182,850.0	43.3	12,089,430.0	33.7	49,437,870.0	26.3
1992	66,711,400.0	27.7	NA	NA	6,947,920.0	32.4	4,007,420.0	33.7	1,357,870.0	43.7	12,313,210.0	33.8	54,398,190.0	26.6
1993	72,162,400.0	28.4	NA	NA	8,655,490.0	35.6	3,430,760.0	31.7	1,491,550.0	44.5	13,577,800.0	35.3	58,584,600.0	27.2
1994	82,131,900.0	29.1	NA	NA	10,401,400.0	36.0	3,189,820.0	34.2	1,669,010.0	47.2	15,260,230.0	36.5	NA	NA
1995	94,484,800.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

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Appendix table 6-4.
High-technology manufacturing in selected industrialized countries, value added and domestic content: 1970-95

	Total manufacturing		Aircraft		Communications		Office & computers		Drugs & medicines		High-tech manufacturing		Other manufacturing	
	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]	Value added (millions of nat'l currency)	Value added/ production (percent)[a]
Spain														
1970	579,816.0	25.4	NA	NA	NA	NA	NA	NA	11,914.3	28.4	NA	NA	NA	NA
1971	656,537.0	25.9	NA	NA	NA	NA	NA	NA	11,983.0	21.0	NA	NA	NA	NA
1972	810,781.0	26.8	NA	NA	NA	NA	NA	NA	16,409.0	24.8	NA	NA	NA	NA
1973	1,005,790.0	27.4	NA	NA	NA	NA	NA	NA	21,130.4	26.7	NA	NA	NA	NA
1974	1,281,930.0	26.1	NA	NA	NA	NA	NA	NA	25,830.8	29.4	NA	NA	NA	NA
1975	1,430,960.0	27.1	NA	NA	NA	NA	NA	NA	29,614.5	31.3	NA	NA	NA	NA
1976	1,713,390.0	27.5	NA	NA	NA	NA	NA	NA	33,523.4	32.6	NA	NA	NA	NA
1977	2,148,850.0	28.6	NA	NA	NA	NA	NA	NA	43,109.3	36.8	NA	NA	NA	NA
1978	3,719,230.0	36.3	7,873.2	67.6	92,189.6	47.0	6,791.4	55.9	73,576.0	49.1	180,430.2	48.8	3,538,799.8	35.8
1979	4,229,370.0	36.8	10,448.9	76.9	94,687.3	48.4	8,194.6	53.0	87,042.0	51.9	200,372.8	51.1	4,028,997.2	36.3
1980	4,977,920.0	36.0	13,242.0	68.6	109,189.0	56.1	8,804.9	42.0	99,517.8	49.2	230,753.7	52.8	4,747,166.3	35.5
1981	5,321,120.0	35.8	18,693.7	65.8	113,029.0	56.9	14,861.5	43.8	121,279.0	52.6	267,863.2	54.5	5,053,256.8	35.1
1982	5,779,520.0	36.5	22,084.0	57.4	133,100.0	53.7	18,439.4	41.0	135,298.0	52.3	308,921.4	52.4	5,470,598.6	35.9
1983	6,541,970.0	36.4	25,394.5	64.2	155,770.0	55.0	20,476.0	48.9	147,872.0	53.1	349,512.5	54.3	6,192,457.5	35.7
1984	6,963,460.0	35.9	21,629.7	67.7	156,185.0	51.5	34,914.9	33.3	154,368.0	54.8	367,097.6	50.8	6,596,362.4	35.3
1985	7,531,800.0	36.2	26,964.2	70.2	154,470.0	50.2	42,962.5	30.1	187,252.0	55.6	411,648.7	49.8	7,120,151.3	35.7
1986	8,322,400.0	40.3	30,872.1	66.5	134,133.0	45.3	34,880.2	29.6	192,557.0	50.5	392,442.3	46.6	7,929,957.7	40.0
1987	9,029,700.0	40.7	35,729.1	60.2	144,252.0	44.3	31,444.4	29.4	217,789.0	50.9	429,214.5	46.7	8,600,485.5	40.5
1988	9,679,100.0	40.5	56,535.0	70.0	182,952.0	46.2	45,087.5	36.0	251,587.0	52.0	536,161.5	49.4	9,142,938.5	40.1
1989	10,675,100.0	40.3	58,861.1	61.6	221,873.0	44.3	55,574.4	42.4	320,233.0	54.5	656,541.5	50.0	10,018,558.5	39.8
1990	11,346,300.0	40.6	76,298.3	66.6	264,633.0	45.7	45,462.4	42.9	377,487.0	57.1	763,880.7	52.3	10,582,419.3	39.9
1991	12,011,700.0	40.9	61,303.8	63.9	240,803.0	46.0	64,162.5	41.0	453,695.0	57.5	819,964.3	52.4	11,191,735.7	40.3
1992	12,380,800.0	42.4	73,806.6	67.9	190,498.0	43.3	35,097.2	26.8	556,604.0	62.9	856,005.8	54.7	11,524,794.2	41.7
1993	12,653,100.0	43.1	NA	NA	229,692.0	44.2	56,937.3	38.1	526,134.0	65.0	NA	NA	NA	NA
1994	13,993,500.0	44.0	NA	NA	269,982.0	44.4	67,821.5	39.5	638,410.0	66.6	NA	NA	NA	NA
1995	16,293,000.0	45.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = not available

NOTE: For U.S. value added, the Organisation for Economic Co-operation and Development reports data supplied by the U.S. Bureau of Economic Analysis on "Gross Product Originating."

[a] The production data used in this calculation are valued in national currency and are maintained by the Organisation for Economic Co-operation and Development in its Structural Analysis Database. These data do not match the production data provided in appendix table 6-5, which are valued in 1987 U.S. dollars.

SOURCE: Organisation for Economic Co-operation and Development, Structural Analysis Database (1996 edition).

See text table 6-2.

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Appendix table 6-5.
Global industry and trade data, by selected countries and industries: 1980-95
(Millions of 1987 U.S. dollars)

Activity and country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
								All manufacturing industries								
Production																
All countries[a]	7,754,045	8,144,508	8,063,357	8,289,382	8,891,805	9,044,120	9,136,926	9,536,219	10,117,377	10,496,222	10,617,686	10,698,977	10,757,128	10,722,920	11,239,430	11,647,170
United States	2,070,477	2,201,960	2,077,227	2,143,027	2,326,374	2,282,612	2,300,127	2,465,600	2,568,882	2,553,131	2,544,395	2,485,743	2,622,845	2,685,838	2,859,185	2,949,769
Canada	173,666	188,763	173,291	183,293	208,511	222,268	230,649	237,541	247,747	243,392	229,974	217,454	223,449	242,460	256,594	267,526
Japan	1,387,623	1,486,046	1,550,489	1,594,840	1,713,927	1,791,557	1,734,699	1,747,725	1,898,321	2,034,442	2,188,385	2,316,907	2,226,411	2,082,610	2,108,386	2,149,120
Germany[b]	637,296	683,703	695,146	708,441	752,312	799,415	794,950	792,963	826,756	882,596	920,154	977,212	947,558	983,256	1,053,734	1,091,743
France	435,143	461,449	478,474	479,285	495,137	501,172	497,227	499,816	524,458	555,932	567,715	571,754	569,432	533,252	554,404	570,845
United Kingdom	348,576	339,809	345,213	358,294	389,559	402,759	400,410	422,852	438,471	448,461	445,029	410,934	435,123	432,630	454,420	472,542
Italy	303,334	312,897	304,996	319,591	347,187	342,220	338,427	345,702	366,457	376,611	366,952	361,669	355,602	347,457	355,722	367,267
China	262,631	243,072	237,225	249,783	244,522	249,616	249,996	274,338	339,767	384,841	313,891	330,941	402,398	541,573	590,053	650,192
South Korea	56,177	66,004	69,885	79,768	92,905	96,487	116,248	138,475	153,162	160,954	177,614	191,979	203,919	220,871	240,551	264,786
Taiwan	71,000	74,776	75,383	83,700	97,038	104,372	128,187	139,648	152,272	152,585	149,580	159,417	158,268	167,748	173,906	186,186
Singapore	13,158	15,048	14,732	15,201	17,375	16,696	19,175	24,209	30,229	28,545	30,165	32,001	33,044	36,695	40,449	44,775
Hong Kong	19,404	23,400	21,411	27,058	27,864	24,962	31,356	36,428	37,173	34,477	32,188	30,364	28,728	28,230	28,229	29,812
Exports																
All countries[a]	1,442,807	1,583,926	1,571,788	1,591,194	1,741,579	1,828,029	1,901,237	2,005,552	2,310,416	2,482,678	2,566,262	2,738,487	2,927,673	3,118,098	3,409,123	3,714,972
United States	205,076	215,057	196,520	180,829	190,702	190,464	200,625	223,520	264,049	305,129	325,537	348,973	375,126	377,147	416,582	467,518
Canada	44,565	50,655	51,778	55,429	66,920	70,194	77,883	76,625	86,283	83,531	87,029	88,615	97,605	105,809	122,345	138,911
Japan	167,319	193,214	193,229	200,055	228,986	240,658	239,059	236,189	256,177	271,250	282,871	286,565	289,159	278,073	278,147	294,184
Germany[b]	201,714	236,978	247,717	242,019	263,450	285,055	279,874	283,854	322,975	344,675	338,540	354,008	357,603	351,484	386,804	412,372
France	102,074	115,528	113,789	114,475	123,326	127,871	125,219	129,568	149,018	159,338	163,496	176,072	184,356	191,650	203,617	217,441
United Kingdom	97,352	92,825	93,078	91,172	98,780	105,171	116,086	121,666	144,213	146,143	153,904	167,575	168,925	174,021	179,349	195,422
Italy	82,515	94,925	95,392	96,995	103,152	112,328	111,828	112,926	127,040	136,181	133,165	136,445	141,531	164,161	176,868	191,834
China	14,390	16,860	16,614	16,623	18,414	15,966	20,939	25,122	38,878	38,979	54,583	63,869	77,492	87,194	107,234	119,935
South Korea	17,633	23,296	25,485	27,608	33,474	34,534	39,268	48,513	59,811	62,943	60,612	66,898	69,541	75,207	83,946	93,778
Taiwan	20,286	22,452	22,073	23,829	28,506	29,328	41,132	56,755	67,491	75,355	76,088	84,905	96,163	100,720	107,293	117,964
Singapore	11,180	12,492	13,177	14,857	17,006	16,498	21,250	25,985	36,375	42,896	45,966	52,626	58,917	69,654	84,947	96,015
Hong Kong	19,453	23,207	23,216	25,108	30,337	31,591	36,790	47,886	62,022	68,659	74,901	86,608	103,239	115,988	124,885	135,950
Imports																
All countries[a]	1,355,470	1,465,746	1,457,058	1,499,989	1,656,996	1,736,679	1,822,093	1,931,793	2,235,044	2,404,720	2,495,021	2,648,558	2,828,165	2,992,882	3,291,253	3,585,730
United States	173,649	204,481	210,587	250,310	324,929	353,212	366,596	365,466	384,887	406,655	396,489	387,994	435,854	489,119	537,703	576,158
Canada	51,245	58,682	50,260	57,261	68,601	71,350	72,911	78,075	90,093	98,754	99,412	100,695	101,563	108,776	123,213	133,322
Japan	47,230	50,930	50,371	52,093	58,471	59,425	70,600	87,645	113,298	127,516	134,680	139,263	140,617	152,266	174,714	197,470
Germany[b]	135,526	133,822	130,627	139,156	144,468	153,151	173,739	185,893	206,584	219,452	250,145	289,071	297,136	290,477	313,343	342,921
France	98,668	104,291	109,703	104,221	107,032	113,643	124,751	135,868	160,660	173,266	180,163	186,363	188,200	186,337	201,498	216,062
United Kingdom	96,239	99,963	101,659	108,492	116,296	121,566	123,549	133,840	168,970	172,383	169,094	163,460	170,521	180,254	191,518	202,162
Italy	66,758	65,862	65,581	64,155	71,448	77,953	83,583	95,307	109,066	118,417	123,532	128,218	132,604	118,890	128,266	139,186
China	14,289	14,604	13,657	16,984	27,482	44,783	40,395	38,940	52,564	53,141	51,077	62,607	80,836	115,361	124,715	137,863
South Korea	13,022	14,866	15,222	17,648	21,232	21,472	24,892	30,324	36,218	41,572	45,731	52,718	49,631	52,659	64,567	76,666
Taiwan	13,436	14,463	13,377	14,835	17,295	16,200	19,659	26,525	34,951	39,898	40,662	46,822	54,346	56,858	60,356	66,577
Singapore	17,715	19,565	21,087	21,974	22,851	21,341	22,172	26,592	33,912	39,341	45,575	51,359	56,768	66,698	77,497	86,354
Hong Kong	22,741	25,879	25,275	26,029	30,677	29,929	32,900	40,676	56,456	56,355	69,827	83,032	99,873	96,913	111,483	122,135

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Appendix table 6-5.

Global industry and trade data, by selected countries and industries: 1980-95

(Millions of 1987 U.S. dollars)

Activity and country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Apparent consumption																
All countries[a]	8,147,070	8,555,504	8,477,702	8,736,480	9,393,800	9,572,261	9,702,883	10,146,039	10,833,030	11,273,876	11,427,213	11,549,155	11,671,095	11,684,724	12,288,728	12,804,129
United States	2,105,792	2,261,665	2,155,857	2,272,144	2,523,681	2,508,602	2,532,981	2,682,354	2,778,412	2,757,552	2,725,599	2,643,581	2,811,863	2,927,328	3,123,907	3,220,240
Canada	191,269	209,252	184,596	198,864	226,800	240,892	245,133	258,238	273,305	279,780	264,567	252,267	252,572	272,835	289,283	300,078
Japan	1,316,536	1,400,492	1,464,516	1,505,936	1,611,164	1,681,672	1,637,217	1,669,374	1,831,589	1,971,387	2,124,376	2,254,859	2,163,972	2,039,724	2,087,976	2,182,756
Germany[b]	662,759	688,175	690,524	715,405	752,801	796,702	815,766	823,871	857,135	914,116	985,762	1,073,180	1,049,783	1,081,847	1,155,929	1,205,635
France	460,046	482,285	506,017	500,939	513,261	522,694	531,883	542,524	578,030	614,728	630,507	631,857	625,556	582,411	609,991	629,634
United Kingdom	377,831	374,487	381,367	402,928	436,728	450,408	442,718	471,733	506,780	519,154	506,901	456,866	487,201	491,016	520,766	538,791
Italy	318,982	320,178	311,857	323,864	355,092	350,927	352,902	371,126	396,969	410,847	408,079	405,491	400,675	364,914	373,110	385,967
China	265,251	244,231	237,968	254,165	257,759	281,979	274,544	294,317	364,063	409,692	325,969	348,929	430,243	597,814	637,164	691,281
South Korea	56,204	63,763	66,428	77,074	89,479	92,618	112,718	133,738	146,083	156,805	179,355	193,297	199,274	214,988	239,496	264,353
Taiwan	70,785	74,193	74,079	82,941	95,695	101,771	121,311	129,701	144,767	145,201	142,585	153,140	153,145	162,367	167,531	178,265
Singapore	21,531	24,180	24,819	24,778	26,042	24,286	23,645	29,161	33,854	32,175	37,478	39,562	40,786	45,422	47,273	51,594
Hong Kong	27,721	32,092	29,514	34,537	36,153	31,610	37,154	41,834	48,264	42,738	47,983	51,656	54,002	48,229	53,933	56,504
High-tech industries[c]																
Production																
All countries[a]	591,039	641,913	678,200	729,533	842,787	874,602	907,164	933,213	1,041,079	1,107,432	1,146,496	1,193,049	1,200,246	1,196,162	1,305,495	1,401,256
United States	215,290	231,553	248,692	264,003	304,695	311,135	320,961	301,400	325,241	327,793	338,027	341,448	363,270	350,016	397,297	444,713
Canada	7,759	8,545	8,077	8,048	9,798	11,080	11,922	13,489	15,031	15,804	16,260	17,178	18,352	17,746	20,317	21,776
Japan	140,544	162,815	175,356	191,578	226,617	235,344	234,575	247,089	283,274	311,087	335,719	361,526	332,368	307,732	320,924	320,202
Germany[b]	47,362	52,883	56,008	62,082	68,079	66,461	65,832	64,024	67,679	75,599	80,798	89,459	85,107	92,529	101,167	106,078
France	26,839	31,102	33,899	32,944	37,722	37,474	37,132	39,629	44,027	48,399	50,140	54,040	52,605	51,125	53,478	56,041
United Kingdom	31,393	31,244	32,572	35,228	40,488	43,895	45,816	49,984	54,628	58,255	59,284	56,133	57,843	56,106	62,200	66,811
Italy	15,910	15,264	14,633	15,822	16,217	14,600	15,406	16,510	19,050	20,593	20,766	19,289	18,346	16,925	17,673	18,806
China	11,609	10,146	10,072	12,781	15,344	24,632	23,939	28,567	38,912	43,833	32,710	35,939	47,162	65,115	71,375	81,341
South Korea	4,107	4,958	5,155	6,813	9,253	9,399	13,326	17,568	21,245	21,526	24,172	24,895	25,946	29,781	34,913	39,632
Taiwan	5,423	5,889	6,020	7,626	9,921	10,437	15,697	19,238	21,880	22,797	23,497	25,258	25,655	31,117	29,779	33,325
Singapore	2,616	2,839	2,748	3,762	5,354	5,432	7,437	10,959	14,686	11,843	12,946	13,501	14,705	17,567	20,459	23,410
Hong Kong	2,333	3,138	2,949	3,670	3,927	2,833	3,856	5,127	5,724	5,019	4,761	4,192	4,288	4,076	4,236	4,688
Exports																
All countries[a]	136,339	158,619	164,430	181,571	215,190	229,221	245,438	272,562	332,394	375,482	403,546	451,551	487,091	523,124	598,881	670,822
United States	35,439	39,139	36,074	40,678	43,934	47,384	51,599	59,628	71,978	80,340	90,147	97,933	105,134	102,639	114,473	128,709
Canada	2,701	3,460	3,816	3,928	4,943	5,370	5,899	6,274	6,788	7,276	8,566	10,005	10,687	10,409	12,591	14,890
Japan	22,258	27,805	28,588	35,077	46,277	47,963	50,338	52,243	62,270	67,584	71,102	74,094	74,862	72,528	74,568	79,652
Germany[b]	14,373	20,405	23,033	22,191	25,195	26,494	23,678	24,426	29,445	33,649	32,459	37,419	36,414	37,051	42,519	46,100
France	7,099	9,063	11,695	10,728	12,907	13,207	12,829	14,719	17,657	20,586	20,296	25,356	26,414	28,196	30,200	32,907
United Kingdom	14,143	13,651	15,069	16,072	18,450	20,862	23,747	21,202	26,665	28,646	30,464	38,745	36,443	39,926	42,834	48,257
Italy	4,355	5,171	5,727	5,799	6,795	8,141	7,639	7,614	9,453	10,489	10,689	10,741	11,375	12,792	13,397	14,887
China	307	336	346	417	713	483	785	1,066	2,269	2,138	4,139	4,780	6,790	7,629	10,458	12,173
South Korea	1,878	2,280	2,229	3,073	4,311	4,486	6,780	9,445	12,967	14,710	14,607	16,798	17,814	18,922	22,893	27,707
Taiwan	2,707	3,009	2,744	3,307	4,214	3,882	6,063	10,035	13,452	15,824	17,016	19,670	23,664	26,072	29,820	34,606
Singapore	2,502	2,356	2,428	3,149	4,104	4,417	6,169	9,146	14,088	17,001	19,649	22,309	26,799	33,388	45,047	51,963
Hong Kong	2,554	2,988	2,754	3,627	5,061	4,745	5,132	7,173	10,660	11,706	13,366	15,036	17,696	20,667	24,888	28,111

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Appendix table 6-5.

Global industry and trade data, by selected countries and industries: 1980-95

(Millions of 1987 U.S. dollars)

Activity and country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Imports																
All countries[a]	121,045	143,141	147,261	165,042	199,632	212,984	230,269	256,721	319,690	361,256	389,724	431,156	466,251	499,417	575,783	645,356
United States	16,953	22,576	24,361	33,224	47,650	50,088	52,738	55,719	64,431	73,906	73,855	78,537	93,060	102,881	116,797	134,379
Canada	5,080	6,207	5,632	6,577	8,493	8,319	9,038	10,222	13,424	13,412	14,828	16,889	17,764	17,539	20,050	23,422
Japan	4,726	5,561	5,332	6,293	6,666	7,491	8,854	10,333	13,279	15,595	18,425	19,171	20,650	23,595	29,425	34,607
Germany[b]	11,513	13,716	13,939	15,326	16,573	18,385	21,101	23,721	27,498	31,511	38,628	42,703	43,018	42,171	47,692	53,577
France	8,254	11,672	13,924	12,206	13,925	14,222	14,319	16,184	22,725	25,967	26,873	32,247	29,542	29,074	31,681	34,978
United Kingdom	10,758	11,441	11,922	14,014	15,892	17,097	17,117	19,775	25,832	29,351	30,230	29,489	30,848	34,268	36,872	38,520
Italy	5,378	6,070	6,150	6,167	7,665	8,752	9,594	11,323	14,115	14,814	16,652	17,785	17,489	15,596	17,024	18,575
China	851	948	784	1,288	3,129	6,104	3,943	4,832	6,321	6,246	6,176	7,866	11,375	16,050	19,394	21,000
South Korea	1,737	1,933	2,041	2,924	3,718	3,558	4,337	5,303	7,577	8,102	8,652	10,142	10,357	10,858	12,987	15,611
Taiwan	1,791	2,080	2,310	2,507	3,135	2,947	3,925	5,403	7,048	8,411	9,078	10,845	12,892	13,932	15,170	16,916
Singapore	2,977	2,974	3,274	4,494	5,121	5,127	5,461	7,120	9,638	11,980	14,448	16,711	18,864	23,358	30,015	34,259
Hong Kong	2,658	2,850	2,785	3,457	4,924	4,457	4,809	6,487	9,891	9,998	12,743	15,512	19,500	19,444	23,111	26,298
Apparent consumption																
All countries[a]	619,157	[illegible]	714,695	772,608	897,756	933,984	971,482	1,005,470	1,134,762	1,214,277	1,262,325	1,318,735	1,340,470	1,346,029	1,481,316	1,605,229
United States	209,338	[illegible]	248,830	269,964	322,943	329,573	339,302	317,448	341,871	348,450	352,266	355,396	387,151	385,506	439,082	494,936
Canada	10,807	[illegible]	10,826	11,664	14,557	15,360	16,517	19,013	23,404	23,786	24,687	26,601	28,179	27,542	31,145	33,801
Japan	129,530	[illegible]	160,516	173,148	200,698	209,092	208,036	220,705	252,792	279,200	304,202	328,645	300,448	280,427	298,039	315,218
Germany[b]	50,890	[illegible]	57,412	65,193	70,756	70,210	73,702	74,125	78,818	88,512	101,405	111,403	107,906	114,507	125,682	133,236
France	29,931	[illegible]	39,333	37,370	42,295	42,134	42,170	45,175	54,000	59,513	62,380	68,015	63,125	59,915	63,439	66,944
United Kingdom	31,537	[illegible]	33,186	37,234	42,571	45,428	45,225	53,658	60,166	65,691	66,050	56,351	60,851	59,867	66,685	69,149
Italy	18,452	17,933	17,088	18,247	19,510	18,132	20,084	22,923	27,076	28,656	30,528	30,149	28,487	24,265	26,145	27,616
China	12,179	10,786	10,542	13,696	17,840	30,311	27,205	32,494	43,342	48,300	35,469	39,911	53,173	75,306	82,854	88,637
South Korea	4,409	5,146	5,423	7,353	9,646	9,670	12,821	15,931	19,389	19,016	22,251	22,822	23,375	26,961	31,022	35,016
Taiwan	4,789	5,291	5,803	7,249	9,608	10,298	15,192	18,115	20,587	21,915	23,192	25,644	26,323	31,403	29,315	32,163
Singapore	3,373	3,691	3,839	5,443	6,778	6,617	7,403	10,044	12,189	9,222	10,607	11,063	10,720	12,563	12,429	13,526
Hong Kong	2,933	3,585	3,514	4,290	4,920	3,586	4,659	6,081	7,299	5,800	7,028	7,854	9,979	7,178	7,882	8,629
								Aircraft								
Production																
All countries[a]	111,561	118,741	121,166	122,112	132,880	143,729	153,164	159,360	170,150	178,634	179,623	181,645	181,957	166,030	181,099	179,616
United States	70,590	74,755	76,806	78,648	85,599	92,782	101,477	103,600	108,325	108,401	113,407	114,356	110,582	92,320	104,937	99,486
Canada	2,226	2,394	1,835	1,613	2,037	2,377	2,813	3,021	3,534	3,915	4,219	3,820	3,509	3,121	4,181	4,245
Japan	2,999	3,463	3,588	3,687	3,977	4,426	4,232	5,026	5,560	5,518	5,464	5,356	5,655	5,461	5,152	5,048
Germany[b]	4,276	4,817	4,734	4,647	4,704	5,473	5,253	6,104	6,318	8,484	8,951	8,946	7,566	7,638	7,430	7,805
France	7,267	9,162	10,410	9,098	10,665	9,243	7,953	8,318	9,814	11,101	10,378	12,122	10,371	9,062	8,614	8,648
United Kingdom	10,519	10,511	10,119	10,309	10,387	11,730	13,478	14,341	14,737	16,242	16,543	15,614	16,318	15,082	15,417	15,955
Italy	3,236	3,138	3,123	2,877	2,934	2,991	3,207	3,205	3,977	4,112	3,423	3,112	2,864	2,552	2,615	2,653
China	3,875	2,982	2,989	3,792	3,808	5,609	5,169	6,086	6,403	7,951	4,783	5,549	11,238	17,489	19,019	21,125
South Korea	1	2	2	2	3	3	3	4	5	5	7	400	290	256	277	317
Taiwan	188	197	194	171	182	208	270	267	259	300	291	335	309	351	329	369
Singapore	92	100	131	173	201	282	306	324	372	297	334	337	454	463	485	539
Hong Kong	0	0	0	1	1	1	1	1	2	2	2	137	157	144	137	149

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Appendix table 6-5.

Global industry and trade data, by selected countries and industries: 1980-95

(Millions of 1987 U.S. dollars)

Activity and country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Exports																
All countries[a]	32,240	40,196	40,149	38,138	39,462	42,051	42,187	40,918	50,264	61,317	65,301	81,445	80,037	69,519	65,930	63,765
United States	15,787	17,684	13,959	14,001	12,239	15,799	17,043	19,717	22,055	26,727	30,577	33,695	34,420	27,664	25,755	20,682
Canada	881	1,099	1,327	1,062	1,080	1,361	1,908	1,700	1,756	1,951	2,592	3,052	2,296	1,924	2,047	2,086
Japan	113	170	243	210	190	167	165	238	337	458	439	511	548	440	426	443
Germany[b]	2,562	6,612	8,637	6,945	7,725	6,487	3,281	3,546	5,569	7,933	6,932	9,239	8,930	7,769	7,399	8,123
France	1,675	2,719	3,457	3,083	4,228	3,444	2,629	3,165	4,963	6,888	5,978	9,097	9,359	9,289	9,481	9,864
United Kingdom	8,162	7,221	7,904	8,203	8,488	9,164	11,331	7,070	8,731	7,882	8,665	15,378	12,527	10,631	9,186	9,946
Italy	483	1,397	1,510	1,322	1,546	1,509	1,194	1,163	1,636	1,917	2,484	2,289	2,387	1,801	1,754	1,894
China	1	2	2	5	47	24	35	6	14	14	23	37	330	163	160	174
South Korea	135	174	65	95	165	279	342	79	121	198	184	231	247	256	246	242
Taiwan	1	1	0	0	1	2	1	2	4	12	16	45	25	35	32	36
Singapore	136	122	86	199	166	384	138	157	181	489	328	250	245	173	181	199
Hong Kong	38	17	23	41	29	37	58	43	59	47	60	50	68	60	52	48
Imports																
All countries[a]	24,744	32,735	31,189	29,274	30,961	33,611	34,717	32,796	45,356	55,752	61,041	70,481	69,421	60,131	58,036	55,130
United States	2,896	4,156	3,882	3,688	4,935	6,532	6,847	5,637	7,120	7,557	8,604	8,761	9,186	8,449	8,032	7,290
Canada	1,393	1,673	1,051	1,179	1,265	1,605	1,713	1,747	3,479	2,524	2,145	2,285	2,253	1,483	1,290	1,552
Japan	1,365	1,732	1,284	1,803	1,366	1,955	2,179	2,197	2,370	2,349	3,578	3,473	3,972	3,035	3,155	2,755
Germany[b]	1,343	3,174	2,939	3,110	2,728	2,859	3,231	3,089	3,910	4,932	6,571	6,556	6,751	5,384	4,872	5,251
France	1,962	4,664	6,410	4,474	5,138	4,590	3,035	3,395	6,525	8,975	8,399	13,183	10,128	8,375	7,608	7,917
United Kingdom	4,119	3,138	2,298	2,927	3,266	3,678	2,992	2,628	4,167	4,614	5,547	4,665	4,371	4,207	4,427	3,706
Italy	730	1,210	979	1,085	1,279	1,250	1,100	998	1,256	1,323	1,766	2,004	1,691	1,241	1,451	1,501
China	197	18	48	302	155	854	676	706	493	798	878	1,185	2,672	2,923	3,387	2,689
South Korea	395	480	306	344	694	600	545	563	1,294	1,335	1,106	1,698	1,761	1,755	1,737	2,126
Taiwan	291	350	640	394	340	429	225	173	179	537	560	1,265	1,359	1,777	1,523	1,683
Singapore	728	472	432	786	859	975	618	571	520	1,276	962	1,337	1,345	1,554	1,375	1,193
Hong Kong	252	140	256	217	239	247	554	393	236	394	580	641	640	775	483	530
Apparent consumption																
All countries[a]	114,369	125,019	126,205	126,323	138,069	149,600	159,553	164,616	181,867	193,813	197,091	197,882	198,231	179,800	195,298	188,953
United States	62,838	67,006	71,316	72,952	82,343	88,761	96,963	96,119	100,798	98,243	101,790	100,894	97,119	82,605	96,092	93,253
Canada	2,951	3,235	1,884	1,991	2,488	2,957	3,092	3,493	5,698	4,980	4,431	3,834	4,056	3,176	3,954	4,344
Japan	4,284	5,076	4,701	5,342	5,209	6,264	6,295	7,056	7,694	7,546	8,733	8,469	9,243	8,188	8,008	7,012
Germany[b]	4,303	4,634	3,319	4,251	3,542	5,050	6,802	7,377	7,395	9,383	11,987	10,825	9,802	8,815	8,296	8,631
France	8,006	11,839	14,300	11,328	12,732	11,332	9,079	9,418	12,749	15,104	14,464	18,744	13,753	10,750	9,394	9,404
United Kingdom	8,511	8,296	6,549	7,175	7,335	8,655	8,159	11,539	12,206	14,690	15,152	8,615	10,957	10,834	12,523	11,485
Italy	3,656	3,460	3,144	3,123	3,233	3,284	3,551	3,466	4,197	4,220	3,617	3,666	3,044	2,652	2,955	2,951
China	4,071	2,999	3,034	4,089	3,921	6,443	5,814	6,787	6,884	8,737	5,642	6,703	13,631	20,275	22,272	20,020
South Korea	354	414	245	281	542	471	492	532	1,189	1,221	1,035	1,937	1,902	1,899	1,901	2,208
Taiwan	478	547	834	565	521	635	494	439	436	827	838	1,563	1,648	2,099	1,826	1,976
Singapore	707	469	491	793	922	937	809	764	737	1,155	1,008	1,439	1,557	1,820	1,661	1,550
Hong Kong	224	129	240	188	218	220	512	363	195	362	538	741	746	849	559	583

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Appendix table 6-5.

Global industry and trade data, by selected countries and industries: 1980-95

(Millions of 1987 U.S. dollars)

Activity and country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Office and computing machinery																
Production																
All countries[a]	89,805	99,954	110,386	124,913	155,235	161,471	160,899	174,946	200,527	217,434	229,330	234,965	238,019	243,951	260,766	285,557
United States	34,411	38,280	43,467	48,789	61,917	61,467	57,879	61,300	68,376	65,876	64,124	58,553	66,038	68,483	78,909	92,324
Canada	935	1,200	1,257	1,286	1,721	1,958	1,869	1,998	2,550	2,563	2,629	2,651	2,945	3,100	3,721	4,325
Japan	30,007	33,944	37,221	39,512	45,612	51,284	52,582	59,340	67,734	78,999	89,183	96,140	91,153	85,975	80,573	81,311
Germany[b]	6,015	7,074	8,099	10,116	13,028	11,721	10,286	9,318	9,951	10,280	10,748	14,799	13,036	15,368	17,346	18,295
France	4,668	5,068	5,043	5,923	6,862	7,211	7,519	8,190	8,353	8,821	8,608	9,365	9,776	10,119	10,670	11,408
United Kingdom	2,729	2,579	3,011	3,949	5,644	7,282	6,833	8,476	10,870	12,204	12,626	12,107	12,514	12,807	14,767	16,382
Italy	2,570	2,692	2,556	3,578	4,161	2,782	2,753	2,858	5,263	5,795	6,041	5,004	4,700	4,814	4,873	5,369
China	401	344	365	438	539	508	554	616	758	742	563	625	803	1,071	1,274	1,514
South Korea	49	62	53	176	367	489	823	839	1,189	1,261	1,368	1,444	1,449	2,826	4,024	4,712
Taiwan	222	267	296	502	883	1,011	2,063	3,046	3,374	3,558	3,870	4,167	4,304	4,885	4,956	5,695
Singapore	73	83	151	398	699	844	1,464	2,284	3,759	4,746	5,603	5,741	6,497	9,259	11,304	13,075
Hong Kong	127	179	187	463	663	396	453	581	990	1,279	2,084	2,139	1,906	1,740	1,773	1,993
Exports																
All countries[a]	25,953	29,754	33,229	42,445	56,513	64,657	71,643	85,254	106,119	119,139	127,802	138,337	152,726	168,741	192,292	219,557
United States	9,381	10,596	11,178	12,817	16,140	17,007	18,022	21,328	26,146	27,113	29,089	30,605	32,704	32,511	36,919	43,865
Canada	736	903	983	1,142	1,453	1,504	1,582	2,060	2,623	2,448	2,748	3,206	3,695	3,841	5,116	6,381
Japan	2,773	3,282	4,354	7,059	10,414	11,245	13,820	16,106	20,042	21,789	23,594	24,039	25,968	26,048	25,839	26,940
Germany[b]	2,943	3,689	4,026	4,779	5,669	7,280	7,338	7,219	7,726	8,614	8,490	9,076	8,435	8,846	10,007	10,714
France	1,607	2,022	2,021	2,567	3,154	3,543	3,954	4,610	4,862	5,293	5,040	5,693	6,039	6,180	6,778	7,503
United Kingdom	2,140	2,120	2,518	3,127	4,603	5,600	5,625	6,868	8,756	10,040	10,057	10,453	10,360	12,250	13,748	15,929
Italy	1,696	1,372	1,582	1,705	2,016	3,017	2,852	2,792	3,552	4,244	3,838	3,856	3,658	4,631	4,707	5,245
China	7	4	5	12	19	11	47	81	224	194	399	543	1,149	1,659	2,436	3,160
South Korea	77	91	127	249	481	655	1,094	1,636	2,590	2,918	2,690	2,889	3,029	3,471	3,448	4,458
Taiwan	191	246	283	478	927	1,181	2,164	4,083	5,897	7,550	9,156	11,176	14,008	15,033	16,969	19,638
Singapore	111	125	229	602	1,059	1,278	2,216	3,457	5,690	7,185	9,097	10,183	13,102	16,979	21,717	25,783
Hong Kong	463	580	526	952	1,571	1,347	1,300	1,738	2,539	2,790	3,234	3,950	4,975	5,379	6,152	6,693
Imports																
All countries[a]	25,288	29,142	32,600	41,793	55,771	63,637	70,479	84,095	104,784	117,522	126,056	136,517	150,459	165,556	189,097	215,887
United States	2,787	3,645	4,703	7,844	11,778	13,023	15,279	18,664	23,229	26,998	28,141	30,472	36,274	42,103	47,755	55,622
Canada	1,437	1,912	2,029	2,315	3,342	3,285	3,333	4,162	4,754	5,080	5,814	6,633	7,236	7,548	8,426	9,620
Japan	1,023	1,142	1,227	1,333	1,604	1,938	2,227	2,679	3,661	4,510	5,102	5,598	5,950	7,073	9,028	10,763
Germany[b]	3,128	3,385	3,502	4,415	5,391	6,565	7,553	8,906	10,332	12,182	14,034	15,878	16,570	16,469	18,200	20,821
France	2,526	2,801	3,246	3,798	4,364	5,017	5,820	6,479	7,946	8,253	8,299	8,229	8,789	9,208	10,851	12,422
United Kingdom	2,906	3,283	3,807	4,877	6,158	6,548	6,864	8,588	10,928	12,486	12,637	12,666	13,547	15,363	15,866	16,884
Italy	1,478	1,650	1,605	1,769	2,495	3,054	3,328	4,131	4,963	4,829	5,085	5,428	5,552	5,152	5,215	5,533
China	126	130	166	211	875	1,055	752	1,031	971	891	889	1,218	1,709	2,359	2,855	3,311
South Korea	157	172	268	410	422	583	900	904	1,340	1,498	1,723	1,830	1,600	1,813	2,382	2,989
Taiwan	143	187	230	299	411	456	689	945	1,384	1,598	1,774	1,974	2,270	2,266	2,608	3,014
Singapore	207	262	393	644	814	923	1,063	1,663	2,542	2,990	4,118	4,564	5,413	6,873	8,447	10,275
Hong Kong	463	439	437	634	1,021	927	780	1,081	1,657	1,654	2,030	2,507	3,655	3,480	4,342	4,988

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Appendix table 6-5.
Global industry and trade data, by selected countries and industries: 1980-95
(Millions of 1987 U.S. dollars)

Activity and country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Apparent consumption																
All countries[a]	97,812	109,320	120,984	138,826	173,861	183,042	184,920	204,326	237,267	259,147	274,307	284,787	293,639	305,913	332,492	368,438
United States	30,869	34,793	40,665	48,043	62,893	63,131	61,144	65,774	74,241	74,905	73,028	68,840	80,792	89,240	102,472	119,265
Canada	1,830	2,433	2,544	2,741	3,959	4,116	4,002	4,624	5,375	5,822	6,382	6,878	7,419	7,777	8,463	9,303
Japan	29,069	32,767	35,375	35,870	39,883	45,310	45,092	50,700	57,311	68,201	77,712	84,851	78,868	74,767	71,474	77,020
Germany[b]	7,324	8,187	9,096	11,554	14,879	13,909	13,445	13,898	15,594	17,251	19,613	25,046	24,316	27,008	30,083	32,124
France	6,027	6,402	6,825	7,862	8,944	9,667	10,482	11,340	12,790	13,256	13,274	13,493	14,218	14,882	16,649	18,129
United Kingdom	3,923	4,097	4,734	6,305	8,184	9,425	9,206	11,640	14,831	16,685	17,212	16,480	17,724	18,400	19,901	21,057
Italy	2,971	3,466	3,153	4,259	5,371	3,921	4,266	5,209	7,970	7,930	8,688	7,982	7,923	7,019	7,116	7,569
China	523	472	529	642	1,404	1,558	1,281	1,605	1,615	1,535	1,250	1,571	1,942	2,613	2,936	3,403
South Korea	172	194	264	475	578	777	1,232	1,040	1,416	1,518	1,931	2,082	1,795	3,102	4,813	5,578
Taiwan	314	387	449	672	1,045	1,149	2,171	2,898	3,181	3,140	3,203	3,164	2,847	3,156	3,059	3,456
Singapore	188	241	353	539	631	702	681	1,068	1,563	1,755	2,149	1,831	1,008	2,001	1,684	1,927
Hong Kong	246	188	234	394	525	331	276	382	777	881	1,735	1,742	1,903	1,265	1,599	1,805
Communications equipment																
Production																
All countries[a]	290,897	316,247	334,407	365,048	431,324	442,150	458,007	454,985	518,277	556,090	578,249	611,493	610,338	614,213	680,801	744,334
United States	87,355	92,424	100,495	106,308	126,020	124,240	125,609	97,200	107,135	110,403	115,578	120,187	134,943	137,208	157,579	196,082
Canada	3,335	3,429	3,425	3,493	4,209	4,517	4,839	5,694	6,133	6,671	6,597	7,920	8,985	8,449	9,163	9,725
Japan	87,834	103,847	111,155	123,447	151,674	153,469	150,053	152,510	178,777	194,236	208,703	227,701	203,181	183,903	201,403	198,080
Germany[b]	27,867	29,829	31,258	34,603	36,251	35,366	37,412	36,809	39,401	43,781	48,374	52,638	51,935	55,766	61,628	64,086
France	11,223	12,322	12,930	12,766	14,900	15,381	15,847	17,356	19,590	21,162	23,340	24,218	23,252	21,942	23,970	25,160
United Kingdom	12,801	12,706	13,465	14,804	17,735	17,814	17,831	18,935	20,404	21,101	21,320	19,482	19,313	18,468	21,614	23,346
Italy	5,773	5,654	5,880	6,432	6,090	6,003	6,612	7,467	7,769	8,791	8,923	8,977	8,560	7,877	8,472	8,991
China	6,667	5,900	5,569	6,866	9,319	17,104	16,274	19,161	27,477	31,198	23,943	25,996	31,431	42,977	47,068	54,174
South Korea	3,116	3,907	3,950	5,362	7,407	7,348	10,752	14,904	17,635	18,273	20,409	20,845	21,883	24,296	28,107	31,880
Taiwan	4,806	5,193	5,235	6,655	8,518	8,839	12,896	15,549	17,825	18,581	18,969	20,380	20,637	25,459	24,074	26,819
Singapore	2,327	2,518	2,321	3,013	4,214	4,075	5,334	7,968	10,178	6,403	6,617	6,892	7,271	7,367	8,179	9,255
Hong Kong	2,154	2,893	2,702	3,163	3,200	2,382	3,335	4,476	4,659	3,668	2,616	1,849	2,156	2,131	2,271	2,487
Exports																
All countries[a]	60,780	68,814	69,104	79,904	97,205	98,693	105,677	120,119	145,809	165,038	179,309	197,561	216,166	241,355	293,514	336,549
United States	7,588	7,965	7,942	10,711	12,290	11,327	12,703	14,882	19,470	22,741	26,583	29,547	33,425	37,829	46,960	59,055
Canada	957	1,272	1,324	1,518	2,225	2,319	2,195	2,277	2,206	2,699	3,008	3,522	4,381	4,313	5,008	5,945
Japan	18,962	23,901	23,540	27,309	35,172	35,996	35,737	35,272	41,207	44,623	46,281	48,687	47,377	45,116	47,414	51,308
Germany[b]	6,152	6,893	7,126	7,146	8,199	8,810	9,027	9,612	11,417	12,408	12,332	13,838	13,627	14,404	18,288	19,840
France	2,195	2,445	2,600	3,008	3,401	3,911	3,853	4,560	5,234	5,591	6,418	7,461	7,517	8,632	9,785	11,095
United Kingdom	2,141	2,368	2,594	2,715	3,228	3,741	4,072	4,603	6,227	7,593	8,555	9,478	9,778	12,716	15,532	17,613
Italy	1,355	1,438	1,645	1,740	2,097	2,310	2,337	2,470	2,954	3,141	3,221	3,399	3,618	4,300	4,758	5,375
China	68	90	103	150	371	107	292	545	1,501	1,345	3,068	3,469	4,494	5,000	6,889	7,765
South Korea	1,645	1,984	2,006	2,696	3,627	3,504	5,270	7,655	10,181	11,507	11,641	13,567	14,408	15,061	19,046	22,837
Taiwan	2,488	2,721	2,424	2,793	3,253	2,669	3,859	5,902	7,495	8,193	7,781	8,375	9,551	10,941	12,749	14,861
Singapore	2,127	1,981	1,969	2,207	2,764	2,625	3,664	5,385	8,040	9,157	10,049	11,702	13,255	15,957	22,812	25,615
Hong Kong	1,901	2,208	2,023	2,444	3,281	3,157	3,518	5,061	7,655	8,486	9,664	10,523	12,070	14,703	18,117	20,735

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Appendix table 6-5.

Global industry and trade data, by selected countries and industries: 1980-95

(Millions of 1987 U.S. dollars)

Activity and country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Imports																
All countries[a]	55,727	63,728	63,704	75,089	92,948	94,269	101,323	115,359	141,360	159,787	172,979	191,586	210,245	232,492	283,892	325,907
United States	10,562	13,842	14,661	20,440	29,458	28,897	28,899	29,672	32,147	37,334	35,043	36,932	44,765	48,983	57,347	67,408
Canada	1,862	2,190	2,068	2,558	3,343	2,935	3,426	3,738	4,515	5,157	6,129	7,150	7,292	7,362	9,116	10,970
Japan	1,134	1,257	1,242	1,651	2,110	1,943	2,453	3,303	4,660	6,308	7,493	7,780	8,187	10,631	14,213	17,864
Germany[b]	5,520	5,597	5,500	6,101	6,627	6,892	7,937	9,297	10,558	11,836	15,238	16,863	16,154	16,726	20,387	22,955
France	2,899	3,178	3,243	2,866	3,336	3,443	4,178	4,954	6,542	6,782	7,979	8,427	7,852	8,344	9,762	10,913
United Kingdom	3,075	4,176	4,719	5,143	5,305	5,611	5,905	7,149	9,005	10,513	10,303	10,180	10,638	11,937	13,629	14,711
Italy	2,415	2,306	2,437	2,244	2,714	3,090	3,562	4,537	5,800	6,545	7,470	7,934	7,451	6,316	7,703	8,590
China	510	766	518	720	2,013	4,074	2,340	2,810	4,437	4,249	4,012	4,935	6,463	10,214	12,557	14,319
South Korea	1,109	1,193	1,353	2,037	2,447	2,227	2,739	3,672	4,729	5,056	5,587	6,326	6,691	6,932	8,473	10,039
Taiwan	1,238	1,398	1,274	1,646	2,191	1,861	2,788	4,047	5,239	6,040	6,499	7,339	8,935	9,524	10,631	11,783
Singapore	1,928	2,117	2,318	2,940	3,317	3,090	3,631	4,728	6,405	7,532	9,198	10,640	11,913	14,655	19,883	22,459
Hong Kong	1,717	2,010	1,834	2,351	3,397	2,979	3,127	4,587	7,524	7,499	9,629	11,733	14,527	14,543	17,555	20,005
Apparent consumption																
All countries[a]	304,878	332,593	350,590	385,539	457,555	468,897	485,963	486,205	556,021	598,496	623,419	662,058	668,692	676,892	758,009	842,802
United States	92,798	100,904	109,824	119,569	147,252	145,571	146,040	116,970	126,352	132,664	133,042	137,632	157,714	161,353	184,154	224,877
Canada	4,471	4,657	4,493	4,906	5,874	5,705	6,615	7,723	8,995	9,810	10,483	12,448	13,022	12,612	14,570	15,776
Japan	75,559	88,220	95,788	105,850	129,019	130,088	127,380	131,023	154,478	169,194	183,689	201,279	178,098	162,871	182,354	193,040
Germany[b]	30,023	31,654	32,858	36,791	38,386	37,429	40,403	40,844	43,711	48,830	56,869	61,931	60,640	64,628	72,032	76,126
France	12,529	13,727	14,288	13,453	15,775	15,996	17,240	19,018	22,355	23,910	26,693	27,270	25,693	24,078	26,699	28,125
United Kingdom	14,329	15,172	16,310	17,985	20,708	20,722	20,794	22,759	24,912	26,131	25,449	22,826	22,903	21,243	24,055	25,699
Italy	7,332	7,052	7,279	7,579	7,481	7,635	8,699	10,445	11,704	13,353	14,359	14,765	13,726	11,478	13,172	14,039
China	7,113	6,582	5,991	7,449	10,999	21,082	18,355	21,493	30,608	34,282	25,315	27,964	34,070	48,964	53,848	60,930
South Korea	2,885	3,487	3,676	5,218	6,926	6,755	9,255	12,435	14,213	14,146	16,734	16,396	17,152	19,304	21,528	24,179
Taiwan	3,998	4,357	4,520	6,012	8,042	8,513	12,527	14,777	16,970	17,948	19,150	20,916	21,828	26,148	24,430	26,730
Singapore	2,478	2,981	2,995	4,111	5,225	4,978	5,913	8,211	9,889	6,312	7,450	7,792	8,155	8,742	9,084	10,048
Hong Kong	2,462	3,268	3,040	3,709	4,176	3,035	3,871	5,336	6,327	4,558	4,755	5,371	7,329	5,063	5,724	6,241
							Drugs and medicines									
Production																
All countries[a]	98,776	106,970	112,241	117,460	123,348	127,252	135,094	143,922	152,126	155,274	159,293	164,947	169,931	171,968	182,830	191,749
United States	23,935	26,094	27,924	30,258	31,160	32,646	35,995	39,300	41,405	43,114	44,918	48,352	51,707	52,005	55,872	56,821
Canada	1,262	1,522	1,560	1,656	1,832	2,228	2,401	2,775	2,814	2,655	2,815	2,787	2,913	3,076	3,251	3,481
Japan	19,704	21,561	23,392	24,932	25,354	26,166	27,708	30,213	31,202	32,334	32,369	32,329	32,379	32,393	33,796	35,762
Germany[b]	9,203	11,164	11,917	12,716	14,096	13,901	12,882	11,794	12,009	13,054	12,725	13,075	12,569	13,757	14,764	15,891
France	3,681	4,550	5,516	5,157	5,296	5,639	5,813	5,764	6,270	7,315	7,815	8,336	9,206	10,002	10,224	10,825
United Kingdom	5,343	5,447	5,978	6,166	6,721	7,068	7,674	8,232	8,616	8,708	8,795	8,931	9,697	9,749	10,402	11,128
Italy	4,331	3,780	3,074	2,935	3,032	2,825	2,833	2,980	2,041	1,895	2,379	2,195	2,222	1,682	1,713	1,792
China	666	921	1,150	1,685	1,678	1,411	1,943	2,704	4,273	3,942	3,421	3,770	3,690	3,577	4,014	4,528
South Korea	940	987	1,150	1,273	1,476	1,558	1,748	1,820	2,416	1,986	2,388	2,206	2,324	2,403	2,505	2,722
Taiwan	208	232	295	298	338	379	469	376	421	358	367	376	404	422	421	442
Singapore	123	139	144	178	240	230	333	384	378	398	392	531	483	478	490	541
Hong Kong	52	66	60	43	63	54	67	69	73	69	60	67	69	61	56	59

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Appendix table 6-5.
Global industry and trade data, by selected countries and industries: 1980-95

(Millions of 1987 U.S. dollars)

Activity and country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Exports																
All countries[a]	17,365	19,856	21,948	21,085	22,010	23,820	25,931	26,271	30,203	29,988	31,134	34,209	38,162	43,509	47,145	50,951
United States	2,683	2,894	2,996	3,149	3,264	3,251	3,829	3,700	4,307	3,759	3,899	4,086	4,584	4,634	4,838	5,107
Canada	127	187	182	206	184	186	213	237	203	177	218	225	315	331	420	478
Japan	411	452	451	500	501	555	616	627	684	714	787	858	970	924	889	960
Germany[b]	2,717	3,211	3,244	3,321	3,602	3,917	4,031	4,049	4,733	4,694	4,706	5,267	5,422	6,033	6,826	7,423
France	1,623	1,877	3,617	2,071	2,124	2,309	2,393	2,384	2,598	2,815	2,860	3,104	3,499	4,094	4,156	4,445
United Kingdom	1,699	1,942	2,053	2,027	2,132	2,356	2,719	2,662	2,951	3,131	3,188	3,436	3,778	4,330	4,368	4,769
Italy	822	965	990	1,032	1,136	1,306	1,256	1,190	1,311	1,187	1,146	1,197	1,712	2,059	2,178	2,373
China	230	240	235	250	276	342	410	433	530	585	648	732	818	807	974	1,075
South Korea	21	30	32	33	38	48	73	75	75	87	92	110	130	134	154	170
Taiwan	28	41	37	36	33	31	39	48	57	68	64	74	80	64	70	71
Singapore	129	127	144	141	115	130	150	147	177	171	174	175	197	280	337	366
Hong Kong	152	184	183	190	180	204	256	331	406	384	407	513	583	525	567	636
Imports																
All countries[a]	15,287	17,536	19,768	18,886	19,952	21,467	23,750	24,470	28,190	28,195	29,647	32,572	36,126	41,238	44,758	48,432
United States	707	933	1,114	1,252	1,480	1,636	1,713	1,746	1,935	2,016	2,067	2,373	2,836	3,347	3,664	4,058
Canada	389	432	484	525	543	494	566	576	675	651	740	821	1,002	1,146	1,218	1,281
Japan	1,204	1,430	1,578	1,506	1,586	1,655	1,995	2,154	2,588	2,427	2,252	2,320	2,541	2,856	3,029	3,225
Germany[b]	1,522	1,561	1,997	1,700	1,827	2,068	2,380	2,429	2,699	2,561	2,785	3,407	3,543	3,592	4,233	4,550
France	867	1,029	1,026	1,068	1,087	1,170	1,286	1,356	1,711	1,958	2,196	2,408	2,774	3,146	3,459	3,726
United Kingdom	657	844	1,099	1,067	1,163	1,260	1,356	1,411	1,732	1,738	1,743	1,978	2,293	2,762	2,950	3,219
Italy	755	904	1,129	1,068	1,177	1,357	1,604	1,657	2,096	2,116	2,330	2,418	2,795	2,886	2,654	2,951
China	19	33	52	56	86	121	175	284	421	307	398	528	531	554	596	681
South Korea	76	88	114	132	155	149	152	163	213	213	236	289	304	359	396	457
Taiwan	118	144	165	167	194	202	223	237	245	236	244	267	328	366	407	437
Singapore	114	122	132	125	130	139	150	159	171	182	170	169	193	277	309	332
Hong Kong	225	261	258	254	267	304	348	426	475	451	504	631	678	646	730	776
Apparent consumption																
All countries[a]	102,098	110,902	116,917	121,920	128,271	132,446	141,045	150,322	159,607	162,822	167,508	174,009	179,908	183,424	195,517	205,037
United States	22,833	25,079	27,026	29,400	30,455	32,110	35,156	38,584	40,480	42,638	44,406	48,030	51,526	52,309	56,365	57,540
Canada	1,555	1,813	1,907	2,025	2,236	2,582	2,807	3,173	3,337	3,173	3,392	3,441	3,682	3,976	4,158	4,377
Japan	20,618	22,673	24,652	26,086	26,587	27,430	29,269	31,926	33,309	34,259	34,068	34,047	34,239	34,601	36,202	38,145
Germany[b]	9,240	10,968	12,139	12,597	13,949	13,822	13,053	12,006	12,118	13,048	12,936	13,600	13,148	14,056	15,271	16,354
France	3,370	4,218	3,920	4,726	4,845	5,139	5,369	5,399	6,106	7,243	7,949	8,508	9,461	10,204	10,696	11,286
United Kingdom	4,772	4,888	5,593	5,769	6,343	6,626	7,065	7,720	8,217	8,185	8,237	8,431	9,267	9,391	10,206	10,908
Italy	4,492	4,005	3,511	3,287	3,425	3,292	3,568	3,802	3,205	3,154	3,864	3,736	3,794	3,117	2,901	3,058
China	472	735	988	1,516	1,517	1,228	1,756	2,610	4,234	3,745	3,262	3,674	3,529	3,454	3,798	4,284
South Korea	999	1,050	1,239	1,379	1,600	1,668	1,842	1,924	2,570	2,130	2,552	2,407	2,526	2,656	2,780	3,051
Taiwan	303	343	430	436	505	557	660	575	621	539	560	584	668	736	773	818
Singapore	130	154	157	185	274	261	357	420	401	437	417	555	511	521	519	573
Hong Kong	165	191	183	157	197	208	226	251	248	237	264	321	319	321	369	387

[a] A total of 68 countries are included.

[b] German data are for the former West Germany only.

[c] High-tech industries include aircraft, office and computing machinery, communication equipment, and drugs and medicines.

SOURCE: WEFA/ICF Global Industry Service (Eddystone, PA: Spring 1997).

See figures 6-2, 6-3, 6-4, 6-5, 6-6, 6-7, 6-8, 6-9, and 6-10.

Appendix table 6-6.

U.S. trade in advanced technology products: 1990-96

(Millions of U.S. dollars)

Product category	1990	1991	1992	1993	1994	1995	1996
U.S. exports							
Total	94,727.6	101,641.5	107,091.3	108,356.6	120,743.3	138,416.5	154,909.2
Biotechnology	661.2	706.0	745.8	892.7	1,029.2	1,055.5	1,197.4
Life science	4,860.3	5,492.5	5,826.0	6,133.7	6,821.3	8,571.5	9,255.6
Opto-electronics	524.0	627.9	604.0	701.7	926.3	1,164.6	1,418.6
Computers and telecommunications	31,375.0	30,726.3	32,569.2	34,198.8	39,859.3	47,890.5	52,780.1
Electronics	7,535.5	8,925.6	9,968.4	11,987.4	16,235.6	31,391.7	36,548.0
Flexible manufacturing	3,095.7	3,251.4	3,412.6	4,039.0	5,191.0	7,469.6	8,583.6
Advanced materials	6,403.0	6,226.1	7,153.6	8,404.2	10,406.2	4,519.5	1,693.6
Aerospace	36,972.7	41,904.5	42,445.5	37,348.1	34,955.4	30,983.1	38,088.7
Weapons	687.9	851.7	784.1	745.1	730.6	1,040.5	1,466.9
Nuclear technology	1,260.5	1,304.2	1,502.4	1,375.6	1,560.6	1,272.0	1,258.9
Software technology	1,351.8	1,625.2	2,079.7	2,530.2	3,027.9	3,057.9	2,617.7
U.S. imports							
Total	59,381.2	63,252.1	71,871.5	81,233.1	98,116.5	124,787.0	130,361.6
Biotechnology	32.1	48.7	48.8	59.2	73.3	444.8	548.8
Life science	3,417.6	4,305.8	4,821.4	4,607.5	4,821.5	6,607.2	7,291.6
Opto-electronics	1,138.0	2,038.4	2,570.3	2,531.0	2,544.1	2,816.6	3,172.8
Computers and telecommunications	30,110.5	29,153.4	33,848.5	39,790.2	49,440.0	58,865.6	61,346.1
Electronics	10,955.3	12,391.7	14,205.3	17,824.2	25,507.3	38,232.6	36,756.8
Flexible manufacturing	1,676.6	1,789.7	1,684.5	2,222.2	2,899.7	4,947.5	5,740.7
Advanced materials	1,045.6	1,051.5	1,548.4	2,052.9	1,091.8	1,527.6	1,219.8
Aerospace	10,713.8	12,106.0	12,687.2	11,613.3	11,135.6	10,540.5	12,805.4
Weapons	129.9	167.8	156.9	164.7	143.9	205.0	265.5
Nuclear technology	4.5	3.0	5.2	7.9	22.7	39.8	626.1
Software technology	157.4	196.0	295.0	360.0	436.5	559.8	588.0
U.S. trade balance							
Total	35,346.4	38,389.4	35,219.8	27,123.6	22,626.8	13,629.5	24,547.6
Biotechnology	629.1	657.3	697.0	833.5	956.0	610.7	648.6
Life science	1,442.8	1,186.7	1,004.6	1,526.2	1,999.7	1,964.3	1,964.1
Opto-electronics	–613.9	–1,410.5	–1,966.3	–1,829.3	–1,617.8	–1,652.0	–1,754.2
Computers and telecommunications	1,264.5	1,572.9	–1,279.3	–5,591.4	–9,580.7	–10,975.1	–8,566.0
Electronics	–3,419.9	–3,466.1	–4,236.9	–5,836.8	–9,271.7	–6,840.9	–208.8
Flexible manufacturing	1,419.1	1,461.7	1,728.1	1,816.8	2,291.3	2,522.1	2,842.9
Advanced materials	5,357.5	5,174.6	5,605.3	6,351.3	9,314.4	2,991.9	473.8
Aerospace	26,258.9	29,798.5	29,758.3	25,734.8	23,819.7	20,442.7	25,283.3
Weapons	558.0	683.9	627.2	580.4	586.7	835.6	1,201.4
Nuclear technology	1,256.0	1,301.1	1,497.2	1,367.7	1,537.9	1,232.2	632.9
Software technology	1,194.5	1,429.2	1,784.7	2,170.3	2,591.4	2,498.1	2,029.7

SOURCE: U.S. Bureau of the Census, Foreign Trade Division <<http://www.fedstats.gov>>, 1997.

See figure 6-11.

Science & Engineering Indicators – 1998

Appendix table 6-7.

U.S. receipts and payments of royalties and fees associated with affiliated and unaffiliated foreign residents: 1987-95

(Millions of U.S. dollars)

	Total	Foreign residents	
		Affiliated	Unaffiliated
Receipts			
1987	9,914	7,629	2,285
1988	11,802	9,156	2,646
1989	13,064	10,207	2,857
1990	16,634	13,251	3,384
1991	18,107	14,395	3,712
1992	19,715	15,718	3,997
1993	20,323	15,707	4,616
1994	22,274	17,422	4,849
1995	26,953	21,619	5,333
Payments			
1987	1,844	1,296	547
1988	2,585	1,410	1,175
1989	2,602	1,778	824
1990	3,135	2,206	929
1991	4,076	2,996	1,080
1992	5,074	3,381	1,694
1993	4,765	3,364	1,401
1994	5,518	3,810	1,708
1995	6,312	5,148	1,163
Balance			
1987	8,070	6,333	1,738
1988	9,217	7,746	1,471
1989	10,462	8,429	2,033
1990	13,499	11,045	2,455
1991	14,031	11,399	2,632
1992	14,641	12,337	2,303
1993	15,558	12,343	3,215
1994	16,756	13,612	3,141
1995	20,641	16,471	4,170

NOTE: Details may not add to totals because of rounding.

SOURCE: U.S. Bureau of Economic Analysis, *Survey of Current Business*, Vol. 76, No. 11 (November 1996).

See figure 6-12. *Science & Engineering Indicators – 1998*

Appendix table 6-8.

U.S. receipts and payments of royalties and license fees generated from the exchange and use of industrial processes with unaffiliated foreign residents, by region/country: 1987-95

(Millions of U.S. dollars)

	Receipts									Payments									Balance								
Region/country	1987	1988	1989	1990	1991	1992	1993	1994	1995	1987	1988	1989	1990	1991	1992	1993	1994	1995	1987	1988	1989	1990	1991	1992	1993	1994	1995
All countries	1,678	1,962	2,051	2,333	2,434	2,525	2,820	3,043	3,316	459	525	612	665	796	818	1,054	1,056	819	1,219	1,437	1,439	1,668	1,638	1,707	1,776	1,987	2,497
Canada	87	60	62	79	62	47	41	53	49	9	11	8	16	11	10	8	11	8	78	49	54	63	51	37	33	42	41
Europe	446	517	530	630	575	637	642	771	737	320	355	433	482	637	635	820	734	482	126	162	97	148	-62	2	-178	37	255
European Union	353	410	378	500	475	498	496	601	652	248	279	342	360	426	417	472	420	401	105	131	36	140	49	81	24	181	251
France	73	82	52	78	91	64	89	129	68	33	37	51	54	73	D	92	104	109	40	45	1	24	18	64	-3	25	-41
Germany[a]	79	73	77	107	97	108	109	142	162	100	112	137	133	182	D	187	128	109	-21	-39	-60	-26	-85	108	-78	14	53
Italy	57	73	68	105	70	99	69	71	58	25	20	22	29	34	24	9	6	7	32	53	46	76	36	75	60	65	51
United Kingdom	60	67	81	91	106	103	103	114	109	72	90	102	111	106	125	123	104	95	-12	-23	-21	-20	0	-22	-20	10	14
All other	93	107	152	130	100	263	272	315	340	72	76	91	122	211	D	409	392	162	21	31	61	8	-111	263	-137	-77	178
So./Central America	64	48	54	59	85	73	D	84	69	5	*	*	*	1	D	D	D	D	59	48	54	59	83	NA	D	NA	NA
Brazil	19	7	14	8	8	6	7	8	8	*	*	*	*	*	*	2	2	2	19	7	14	8	8	6	5	6	6
Mexico	14	13	18	23	31	29	28	33	22	3	*	*	*	*	1	*	1	D	11	13	18	23	30	28	28	32	NA
All other	31	28	22	28	46	38	D	43	39	2	NA	NA	NA	1	D	D	D	D	29	28	22	28	45	38	D	NA	NA
Africa	D	22	24	22	34	27	36	26	21	*	4	*	0	*	*	*	1	*	0	18	24	22	34	27	36	25	21
Middle East	D	18	17	22	25	21	33	21	38	2	3	4	3	4	5	9	9	15	-2	15	13	19	21	16	24	12	23
Asia & the Pacific	936	1,185	1,248	1,465	1,638	1,704	1,966	2,077	2,382	95	112	120	160	140	152	200	283	299	841	1,073	1,128	1,305	1,498	1,552	1,766	1,794	2,083
Hong Kong	4	6	7	6	6	11	12	8	21	1	*	*	0	*	*	2	3	D	3	6	7	6	6	11	10	5	NA
India	18	40	26	21	14	34	D	28	35	*	*	*	*	*	*	0	*	*	18	40	26	21	14	34	NA	28	35
Indonesia	5	5	8	11	20	13	20	20	14	0	*	0	0	0	*	0	0	*	5	5	8	11	20	13	20	20	14
Japan	723	883	897	1,028	1,219	1,268	1,434	1,373	1,501	88	108	109	141	138	145	191	262	280	635	775	788	887	1,081	1,123	1,243	1,111	1,221
Malaysia	*	*	2	2	2	7	18	19	D	0	0	0	0	0	0	*	0	*	NA	0	2	2	2	7	18	19	NA
The Philippines	3	4	4	4	2	3	D	1	5	0	*	1	0	0	*	*	*	*	3	4	3	4	2	3	NA	1	5
Singapore	30	13	8	19	21	20	20	73	32	*	0	0	0	*	D	*	*	*	30	13	8	19	21	20	20	73	32
South Korea	34	107	167	249	225	220	278	416	585	*	*	D	D	*	1	1	6	D	34	107	167	249	225	219	277	410	NA
Taiwan	21	46	34	55	57	42	34	39	65	*	*	D	1	*	2	2	2	*	21	46	34	54	57	40	32	37	65
All other	98	81	95	70	72	86	D	100	D	6	4	10	D	2	D	4	10	NA	92	77	85	70	70	86	NA	90	NA
All other	145	112	116	56	15	16	NA	11	20	28	40	47	7	58	NA	NA	NA	NA	117	72	69	52	13	NA	NA	NA	NA

* = less than $500,000; D = withheld to avoid disclosing operations of individual companies; NA = not available

NOTE: Industrial processes include patents and other proprietary inventions and technology.

[a] German data prior to 1990 are for the former West Germany only. Beginning in 1990, these data are also for the former East Germany.

SOURCE: U.S. Bureau of Economic Analysis, *Survey of Current Business*, Vol. 76, No. 11 (November 1996): 90-93.

See figure 6-13.

Science & Engineering Indicators – 1998

Appendix table 6-9.

R&D performance in the United States, by industry: 1973-94

(Millions of current purchasing power parity dollars)

Industry	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Total, all industries	21,250	22,887	24,206	26,997	29,825	33,304	38,226	44,505	51,810	58,650	65,268	74,800	84,239	87,823	92,155	97,015	102,055	109,727	116,952	119,110	117,400	119,595
Total manufacturing	20,535	22,119	23,471	26,151	28,867	32,075	36,686	42,690	49,904	56,178	61,931	69,895	77,525	80,377	84,311	86,502	88,024	88,934	88,506	90,177	90,932	96,307
Food, drink & tobacco	269	298	335	355	415	472	528	620	638	779	827	1,082	1,136	1,286	1,206	1,229	1,275	1,414	1,277	1,386	1,345	1,476
Textiles, footwear & leather	64	69	70	82	83	89	101	115	116	136	150	182	218	246	243	260	260	297	283	275	313	344
Wood, cork & furniture	71	84	88	107	123	126	139	148	161	159	152	143	147	144	137	173	197	245	210	247	259	269
Paper & printing	194	237	249	313	333	387	445	495	566	566	552	593	576	541	604	788	879	1,059	1,235	1,245	1,643	1,723
Chemicals	3,040	3,541	3,907	4,285	4,611	5,133	5,877	6,844	8,335	9,516	10,219	11,027	11,436	11,582	12,139	13,816	15,134	16,750	18,382	18,981	20,706	20,701
Industrial chemicals	1,418	1,643	1,766	1,925	2,085	2,272	2,521	2,859	3,540	4,112	4,272	4,608	5,056	5,185	5,535	6,161	6,261	7,004	7,587	7,437	8,248	7,557
Pharmaceuticals	698	807	981	1,091	1,117	1,308	1,517	1,777	2,085	2,492	2,913	3,319	3,484	3,658	4,100	4,906	5,808	6,287	7,061	7,944	9,146	9,633
Petroleum refining	498	622	693	767	918	1,060	1,262	1,552	1,936	2,141	2,258	2,312	2,220	2,018	1,897	1,997	2,180	2,306	2,498	2,277	2,152	1,950
Rubber & plastics products	426	469	467	502	491	493	577	656	775	771	776	788	676	721	607	752	885	1,153	1,236	1,323	1,161	1,561
Stone, clay & glass	199	217	233	263	287	324	356	406	460	513	624	733	835	950	995	738	637	616	483	510	538	591
Basic metal industries	308	358	443	506	538	560	634	728	878	987	1,085	717	740	803	730	637	686	739	714	522	669	690
Ferrous metals	163	181	215	256	284	314	375	443	555	613	637	381	324	345	252	253	251	238	228	224	289	247
Nonferrous metals	145	177	228	250	254	246	259	285	323	374	448	336	416	458	478	384	435	501	486	298	380	443
Fabricated metal products and machinery	16,232	17,138	17,941	20,023	22,234	24,718	28,318	32,970	38,306	43,003	47,780	55,040	62,076	64,443	67,874	68,440	68,507	67,201	65,297	66,351	64,628	69,645
Fabricated metal products	291	313	324	358	386	384	455	550	624	625	701	842	829	895	783	881	904	939	974	1,017	1,158	1,111
Nonelectrical machinery	816	882	976	1,085	1,225	1,400	1,611	1,939	2,417	2,411	2,392	2,404	2,394	2,396	2,428	2,682	2,729	2,753	3,555	3,534	3,431	4,004
Office machinery & computers	1,733	2,103	2,220	2,402	2,655	2,883	3,214	3,962	4,401	5,667	6,635	8,100	9,822	9,794	9,347	10,444	11,705	11,693	11,220	11,404	9,313	9,664
Electrical machinery	1,834	2,047	2,121	2,382	2,295	2,476	2,775	3,048	3,476	2,858	2,815	1,848	1,277	1,250	1,239	1,419	2,126	3,444	3,091	2,722	2,537	2,664
Electronic equipment & components	3,068	2,964	2,984	3,254	3,591	4,031	5,049	6,127	6,853	8,065	9,866	11,930	13,155	13,730	14,609	12,709	11,192	9,956	10,324	10,638	10,812	12,674
Shipbuilding	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Motor vehicles	2,405	2,389	2,340	2,778	3,358	3,879	4,509	4,955	4,806	4,797	5,318	6,057	6,984	9,732	9,279	10,085	11,020	10,256	10,388	9,924	11,793	13,406
Aerospace	5,052	5,278	5,713	6,339	7,033	7,536	8,041	9,198	11,968	14,451	15,406	18,858	22,231	21,050	24,458	24,168	22,331	20,635	16,629	17,158	15,056	14,260
Transport equipment	72	87	90	94	120	131	159	162	147	199	381	399	371	493	509	522	508	470	411	412	409	421
Instruments	961	1,075	1,173	1,331	1,571	1,998	2,505	3,029	3,614	3,930	4,266	4,602	5,013	5,103	5,222	5,530	5,992	7,055	8,705	9,542	10,119	11,441
Other manufacturing	158	177	205	217	243	266	288	364	444	519	541	379	361	382	383	420	449	613	624	660	831	868
Total services	715	768	735	845	958	1,229	1,540	1,815	1,906	2,472	3,337	4,905	6,714	7,446	7,844	10,513	14,031	20,793	28,446	28,933	26,468	23,288

SOURCE: Organisation for Economic Co-operation and Development, Analytical Business Enterprise R&D Database (Paris: April 1997).

See figure 6-15.

Science & Engineering Indicators – 1998

Appendix table 6-10.

R&D performance in Japan, by industry: 1973-94

(Millions of current purchasing power parity dollars)

Industry	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Total, all industries	5,052	5,559	6,037	6,643	7,445	8,322	10,249	12,536	15,257	17,703	20,411	23,284	27,283	28,313	30,945	35,483	41,400	47,450	50,304	51,203	49,123	49,590
Total manufacturing	4,792	5,287	5,692	6,289	7,027	7,889	9,725	11,906	14,580	16,978	19,545	22,296	26,282	27,278	29,862	34,176	39,891	45,575	48,418	49,016	46,892	47,373
Food, drink & tobacco	137	135	165	180	204	223	287	389	419	500	536	603	670	741	921	961	1,102	1,205	1,164	1,242	1,363	1,291
Textiles, footwear & leather	82	73	81	74	67	88	126	136	271	227	228	270	287	290	317	358	409	452	474	635	505	424
Wood, cork & furniture	12	15	22	26	29	34	41	44	52	57	92	60	56	72	77	88	151	126	160	147	168	177
Paper & printing	99	63	69	62	70	71	74	86	87	121	166	195	233	233	263	335	398	442	473	400	394	405
Chemicals	1,135	1,299	1,419	1,516	1,702	1,831	2,290	2,845	3,172	3,661	4,180	4,720	5,282	5,562	6,371	7,164	8,199	8,900	9,769	10,412	10,208	10,365
Industrial chemicals	674	787	813	855	937	979	1,203	1,470	1,677	1,962	2,169	2,527	2,730	2,968	3,408	3,804	4,314	4,612	4,944	5,148	5,058	5,058
Pharmaceuticals	250	277	341	387	425	489	680	757	918	1,051	1,298	1,339	1,570	1,582	1,814	2,046	2,293	2,643	3,047	3,446	3,414	3,494
Petroleum refining	50	54	61	64	95	90	100	259	171	191	223	254	313	317	334	368	423	471	457	482	444	438
Rubber & plastics products	161	181	204	210	244	273	306	359	406	457	491	600	668	695	815	946	1,169	1,175	1,321	1,336	1,292	1,375
Stone, clay & glass	108	133	150	184	186	212	280	332	353	410	507	595	800	868	848	976	1,113	1,102	1,341	1,148	1,077	1,009
Basic metal industries	310	375	413	453	475	517	614	806	998	1,117	1,164	1,268	1,566	1,691	1,666	1,819	1,987	2,275	2,628	2,452	2,358	2,085
Ferrous metals	231	281	320	352	366	392	461	587	713	801	833	871	1,104	1,181	1,168	1,227	1,348	1,556	1,859	1,668	1,552	1,313
Nonferrous metals	78	94	93	101	109	125	152	219	284	316	331	397	462	510	498	591	639	720	769	783	805	773
Fabricated metal products and machinery	2,858	3,134	3,307	3,724	4,214	4,822	5,919	7,128	9,086	10,723	12,504	14,384	17,176	17,578	19,140	22,197	26,220	30,715	32,008	32,167	30,426	31,144
Fabricated metal products	80	81	105	143	136	145	210	208	272	284	371	378	472	438	452	440	550	664	709	679	653	617
Nonelectrical machinery	466	647	683	663	843	764	936	1,174	1,389	1,596	1,772	1,997	2,300	2,341	2,536	2,779	3,389	4,104	4,334	4,265	4,349	4,615
Office machinery & computers	148	109	157	192	239	283	362	449	583	715	901	1,377	1,590	1,721	2,224	2,962	4,087	4,584	4,812	4,413	4,351	4,294
Electrical machinery	570	558	597	728	809	970	1,198	1,122	1,437	1,691	2,048	2,439	2,830	2,866	3,172	3,646	4,356	5,101	5,215	5,181	5,266	5,561
Electronic equipment & components	756	865	818	989	922	1,082	1,357	1,980	2,521	3,196	3,760	4,158	5,173	5,135	5,585	6,311	6,656	7,434	8,078	8,545	7,690	8,190
Shipbuilding	44	46	45	41	35	30	31	34	34	41	52	40	50	38	42	46	59	66	76	103	99	87
Motor vehicles	590	631	685	761	926	1,177	1,379	1,601	2,102	2,374	2,576	3,019	3,494	3,697	3,774	4,523	5,389	6,547	6,527	6,785	5,798	5,519
Aerospace	56	62	74	27	67	73	94	91	103	120	198	103	176	250	282	240	311	407	549	353	381	316
Transport equipment	28	12	14	26	36	46	54	72	113	119	117	111	165	170	100	75	85	89	89	92	95	104
Instruments	120	121	129	153	202	251	297	396	533	588	711	759	926	921	973	1,173	1,338	1,719	1,621	1,752	1,744	1,842
Other manufacturing	53	59	67	69	80	89	95	138	142	161	167	201	212	244	260	279	312	356	400	415	393	473
Total services	225	220	294	299	373	373	464	559	602	637	770	884	881	916	961	1,130	1,362	1,667	1,648	1,993	2,034	2,042

SOURCE: Organisation for Economic Co-operation and Development, Analytical Business Enterprise R&D Database (Paris: April 1997).

See figure 6-15.

Science & Engineering Indicators – 1998

Appendix table 6-11.
R&D performance in the European Union, by industry: 1973-94
(Millions of current purchasing power parity dollars)

Industry	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Total, all industries	12,282	13,777	15,467	17,134	18,782	21,543	25,759	28,828	32,759	36,067	38,292	42,036	47,819	51,872	55,935	60,724	66,263	71,186	73,569	78,669	76,804	77,813
Total manufacturing	11,201	12,632	14,047	15,551	17,016	19,682	23,429	26,505	30,062	33,094	35,185	38,801	44,001	46,241	49,994	54,249	59,107	63,665	65,399	68,365	66,476	67,486
Food, drink & tobacco	247	297	328	363	390	452	520	574	594	632	646	750	826	887	938	981	1,134	1,214	1,245	1,368	1,408	1,413
Textiles, footwear & leather	133	161	161	158	152	173	181	167	169	178	192	220	235	245	241	248	252	262	341	365	397	447
Wood, cork & furniture	14	16	16	17	20	37	55	61	64	76	85	100	119	121	122	122	129	130	157	160	160	184
Paper & printing	82	88	95	101	109	128	155	172	188	206	221	245	263	281	307	318	362	400	394	393	379	422
Chemicals	2,824	3,232	3,707	4,149	4,554	5,071	5,776	6,516	7,586	8,339	8,748	9,536	10,724	11,396	12,698	14,138	15,417	16,632	16,783	17,889	17,596	17,667
Industrial chemicals	1,641	1,913	2,205	2,476	2,689	2,869	3,167	3,639	4,257	4,597	4,732	5,227	5,942	6,308	6,896	7,563	8,006	8,366	8,284	8,528	8,112	8,099
Pharmaceuticals	753	855	990	1,121	1,248	1,521	1,801	1,944	2,205	2,526	2,788	3,003	3,353	3,638	4,341	5,004	5,674	6,423	6,694	7,565	7,683	7,819
Petroleum refining	223	241	267	291	300	318	354	403	514	545	552	588	637	647	639	669	711	805	821	781	715	645
Rubber & plastics products	208	224	244	261	316	363	454	530	610	672	677	718	791	803	821	902	1,026	1,038	984	1,015	1,086	1,104
Stone, clay & glass	156	177	182	193	210	250	302	332	359	392	424	444	479	475	514	547	619	617	647	682	670	691
Basic metal industries	312	395	433	454	467	506	586	650	733	799	846	867	918	911	937	1,002	1,045	1,080	1,106	1,124	1,041	1,089
Ferrous metals	223	262	297	305	309	334	404	441	504	547	581	592	637	619	634	692	713	717	770	811	738	787
Nonferrous metals	89	133	135	149	159	172	182	208	229	252	265	275	281	292	303	309	332	363	336	313	303	302
Fabricated metal products and machinery	7,377	8,209	9,061	10,021	10,998	12,937	15,732	17,899	20,259	22,356	23,900	26,525	30,320	31,787	34,076	36,738	39,993	43,150	44,547	46,184	44,616	45,358
Fabricated metal products	117	139	164	189	222	305	415	490	574	688	754	802	900	928	957	1,019	1,086	1,231	1,110	1,128	1,125	1,184
Nonelectrical machinery	820	893	986	1,065	1,201	1,521	1,952	2,162	2,412	2,690	2,846	3,006	3,402	3,558	3,907	4,362	5,000	5,079	5,267	5,819	5,670	5,899
Office machinery & computers	374	415	481	596	731	816	932	1,004	1,166	1,326	1,460	1,755	2,074	2,107	2,302	2,604	2,851	2,980	3,118	3,036	2,761	2,470
Electrical machinery	993	1,159	1,282	1,400	1,462	1,650	1,867	2,059	2,320	2,578	2,722	3,115	3,751	4,220	4,439	4,508	4,437	4,445	5,232	5,249	5,214	5,251
Electronic equipment & components	1,796	2,077	2,378	2,637	2,934	3,649	4,520	5,262	5,993	6,583	7,138	7,786	8,685	8,843	9,652	10,317	11,042	11,888	11,294	11,719	11,446	11,967
Shipbuilding	86	88	88	92	95	93	86	90	95	110	122	140	145	158	152	139	157	196	180	240	233	239
Motor vehicles	1,263	1,361	1,489	1,667	1,901	2,211	2,673	2,993	3,371	3,816	4,192	4,696	5,288	5,656	6,147	6,925	7,751	8,592	9,306	10,170	10,262	10,425
Aerospace	1,695	1,825	1,920	2,074	2,117	2,303	2,823	3,310	3,730	3,914	3,997	4,492	5,246	5,455	5,621	5,892	6,649	7,553	7,681	7,392	6,403	6,358
Transport equipment	24	28	29	44	63	62	66	75	90	108	132	153	155	161	171	175	167	207	322	294	312	339
Instruments	209	224	242	258	273	327	397	453	509	543	537	579	675	702	727	795	852	980	1,036	1,137	1,190	1,225
Other manufacturing	56	58	64	94	117	129	120	134	110	118	122	114	118	138	162	156	156	179	180	199	207	216
Total services	749	868	1,003	1,128	1,300	1,387	1,518	1,618	1,849	2,093	2,289	2,454	2,853	4,634	4,948	5,614	6,292	6,626	7,147	8,613	9,114	9,121

NOTE: The member countries of the European Union are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

SOURCE: Organisation for Economic Co-operation and Development, Analytical Business Enterprise R&D Database (Paris: April 1997).

See figure 6-15.

Science & Engineering Indicators – 1998

Appendix table 6-12.

Number of U.S. patents granted, by inventor residence, inventor sector, and year of grant: 1963-95

Inventor residence/sector	Total 1963-95	1963-82	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
TOTAL	2,401,282	1,234,646	57,888	56,860	67,200	71,661	70,860	82,952	77,924	95,537	90,364	96,513	97,441	98,342	101,675	101,419
Inventor residence																
U.S. origin	1,497,969	865,097	33,896	32,871	38,367	39,555	38,126	43,520	40,496	50,185	47,387	51,182	52,252	53,231	56,065	55,739
Foreign origin	903,313	369,549	23,992	23,989	28,833	32,106	32,734	39,432	37,428	45,352	42,977	45,331	45,189	45,111	45,610	45,680
Argentina	698	417	18	21	20	11	17	18	16	20	17	16	20	24	32	31
Australia	9,010	3,584	266	237	292	340	374	389	416	503	432	463	410	378	467	459
Austria	8,653	4,083	229	267	256	318	357	345	337	399	393	359	370	313	289	338
Belgium	8,626	4,459	224	205	240	240	243	295	302	359	313	324	324	350	351	397
Brazil	874	330	27	19	20	30	27	34	29	36	41	61	40	57	60	63
Bulgaria	465	246	13	19	22	21	21	32	23	16	27	10	5	5	4	1
Canada	43,063	20,252	990	1,000	1,206	1,342	1,314	1,594	1,489	1,959	1,862	2,035	1,964	1,944	2,008	2,104
China	545	107	0	1	2	1	9	23	47	52	47	52	41	53	48	62
Czechoslovakia	2,090	1,637	50	38	33	54	35	46	33	34	39	27	17	13	19	15
Denmark	5,026	2,521	121	125	150	187	182	204	151	221	158	210	193	197	207	199
Finland	4,843	1,330	125	116	167	200	210	275	232	230	304	331	360	293	312	358
France	72,156	35,247	1,975	1,895	2,162	2,400	2,369	2,874	2,661	3,140	2,866	3,030	3,029	2,908	2,779	2,821
Germany	188,830	91,571	5,467	5,477	6,323	6,718	6,856	7,885	7,353	8,353	7,612	7,680	7,310	6,893	6,732	6,600
Hong Kong	843	243	18	14	24	25	31	34	41	48	52	50	60	60	57	86
Hungary	2,242	901	112	106	111	108	131	127	94	129	93	85	88	61	46	50
India	492	231	4	14	12	10	18	12	14	14	23	22	24	30	27	37
Ireland	862	268	24	18	29	30	28	38	43	65	54	55	55	53	50	52
Israel	4,866	1,317	114	109	162	179	189	245	238	326	299	305	335	314	350	384
Italy	26,920	11,960	752	625	794	919	995	1,183	1,076	1,297	1,260	1,209	1,271	1,286	1,215	1,078
Japan	313,267	77,458	8,149	8,793	11,110	12,746	13,209	16,557	16,158	20,168	19,525	21,027	21,926	22,293	22,384	21,764
Liechtenstein	473	274	19	12	16	13	16	16	10	11	15	11	16	11	16	17
Luxembourg	567	198	26	27	24	37	31	22	29	29	17	27	26	28	22	24
Mexico	1,614	1,076	35	32	42	32	37	49	44	39	32	28	39	45	44	40
Netherlands	22,609	11,104	619	626	726	766	722	922	806	1,060	959	992	854	801	853	799
New Zealand	1,107	452	44	38	50	33	52	68	55	58	52	41	44	39	37	44
Norway	2,890	1,415	65	66	87	90	81	135	121	126	112	111	108	117	126	130
Poland	626	451	26	20	15	11	14	13	8	14	17	8	5	8	8	8
South Africa	2,615	1,238	73	60	82	96	88	107	103	134	115	105	97	93	101	123
South Korea	4,649	102	14	26	30	41	46	84	97	159	225	404	538	779	943	1,161
Spain	2,798	1,219	49	50	69	78	97	115	126	131	130	153	133	159	141	148
Sweden	23,939	13,370	685	623	701	857	883	948	777	837	768	716	627	635	706	806
Switzerland	38,553	21,623	1,147	1,017	1,174	1,233	1,212	1,373	1,245	1,363	1,284	1,335	1,196	1,126	1,169	1,056
Taiwan	9,229	316	88	65	99	174	208	343	457	591	732	904	1,030	1,189	1,443	1,620
United Kingdom	85,837	51,143	2,132	1,930	2,269	2,494	2,405	2,775	2,579	3,094	2,789	2,799	2,425	2,294	2,234	2,475
U.S.S.R.	6,963	5,129	209	222	214	147	116	121	96	161	174	178	66	65	53	12
Venezuela	414	135	10	5	11	15	21	24	20	23	20	25	22	31	23	29
Others (113 countries)	4,059	2,142	73	71	89	110	90	107	102	153	119	143	151	166	254	289
Inventor sector																
U.S. corporation	1,145,904	654,518	25,783	25,677	29,999	31,181	29,490	33,726	31,437	38,664	36,093	39,133	40,307	41,826	44,035	44,035
U.S. government	44,445	29,623	1,005	1,048	1,235	1,139	1,022	981	733	880	983	1,183	1,161	1,166	1,258	1,028
U.S. individual	365,564	211,276	8,553	7,574	8,911	9,265	9,477	10,887	10,122	13,028	12,542	13,207	12,751	12,281	12,805	12,885
Foreign corporation	711,249	269,314	18,856	19,246	23,238	25,957	26,545	32,371	30,960	37,506	35,548	37,594	38,237	38,401	38,788	38,688
Foreign government	9,638	3,748	369	339	438	483	479	555	453	441	423	472	463	434	296	245
Foreign individual	124,482	66,167	3,322	2,976	3,379	3,636	3,847	4,432	4,219	5,018	4,775	4,924	4,522	4,234	4,493	4,538

SOURCE: U.S. Patent and Trademark Office, *Patenting Trends in the United States, 1963-95* (Washington, DC: 1996).

See figures 6-16, 6-17, and 6-18.

Appendix table 6-13.

Patent classes most emphasized by inventors from the United States patenting in the United States: 1985 and 1995

Patent class number and title		Patents granted to inventors from: All countries 1985	All countries 1995	United States 1985	United States 1995	Activity index 1985	Activity index 1995
166	Wells	336	338	306	285	1.783	1.667
606	Surgery	154	602	103	484	1.310	1.590
604	Surgery	298	843	232	674	1.524	1.581
607	Surgery: light, thermal, and electrical application	94	293	71	211	1.479	1.424
585	Chemistry of hydrocarbon compounds	225	223	168	158	1.462	1.401
206	Special receptacle or package	262	404	183	280	1.368	1.370
128	Surgery	290	846	164	582	1.107	1.360
220	Receptacles	182	230	101	155	1.087	1.332
248	Supports	211	247	135	166	1.253	1.329
380	Cryptography	47	204	34	137	1.416	1.328
052	Static structures (e.g., buildings)	313	315	201	207	1.257	1.299
426	Food or edible material: processes, compositions, and products	438	479	287	309	1.283	1.275
273	Amusement devices: games	108	331	65	213	1.178	1.272
134	Cleaning and liquid contact with solids	84	224	58	144	1.352	1.271
436	Chemistry: analytical and immunological testing	126	280	90	180	1.399	1.271
326	Electronic digital logic circuitry	115	333	67	211	1.141	1.253
435	Chemistry: molecular biology and microbiology	385	1,346	229	852	1.165	1.252
530	Chemistry: natural resins or derivatives; peptides	134	271	85	171	1.242	1.248
342	Communications: directive radio wave systems and devices	109	274	57	172	1.024	1.241
395	Information processing system organization	550	3,025	355	1,874	1.264	1.225
062	Refrigeration	423	515	240	315	1.111	1.209
210	Liquid purification or separation	452	782	254	478	1.100	1.209
239	Fluid sprinkling, spraying, and diffusing	230	240	132	146	1.124	1.203
424	Drug, bio-affecting and body treating compositions	404	1,166	221	705	1.071	1.195
015	Brushing, scrubbing, and general cleaning	135	229	84	138	1.218	1.192
362	Illumination	171	330	109	199	1.248	1.192
379	Telephonic communications	244	733	147	438	1.180	1.181
297	Chairs and seats	154	223	69	132	0.877	1.170
361	Electricity: electrical systems and devices	463	763	269	450	1.138	1.166
200	Electricity: circuit makers and breakers	273	207	159	122	1.140	1.165
340	Communications: electrical	381	598	184	351	0.946	1.161
137	Fluid handling	531	427	324	250	1.195	1.158
235	Registers	106	321	46	187	0.850	1.152
029	Metal working	604	699	365	404	1.183	1.143
536	Organic compounds—part of the class 532–570 series	95	320	39	183	0.804	1.131
174	Electricity: conductors and insulators	201	349	120	199	1.169	1.127
280	Land vehicles	285	581	93	331	0.639	1.126
439	Electrical connectors	496	810	349	459	1.378	1.120
073	Measuring and testing	938	1,100	526	619	1.098	1.113
053	Package making	289	351	138	197	0.935	1.110
324	Electricity: measuring and testing	409	893	237	501	1.135	1.109
315	Electric lamp and discharge devices: systems	236	332	145	185	1.203	1.102
162	Paper making and fiber liberation	163	208	75	115	0.901	1.093
502	Catalyst, solid sorbent, or support therefor: product	425	302	279	167	1.285	1.093
341	Coded data generation or conversion	170	280	84	152	0.968	1.073
330	Amplifiers	247	241	119	130	0.943	1.067
427	Coating processes	555	691	298	370	1.051	1.059
385	Optical waveguides	178	504	100	269	1.100	1.055
568	Organic compounds—part of the class 532–570 series	365	302	221	160	1.186	1.048
156	Adhesive bonding and miscellaneous chemical manufacture	546	779	327	412	1.173	1.046
414	Material or article handling	316	324	170	171	1.053	1.044

NOTES: The activity index is the percentage of the patents in a class that are granted to inventors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to U.S. Patent and Trademark Office classes that received at least 200 patents from all countries in 1995.

SOURCE: U.S. Patent and Trademark Office, Office of Information Systems, TAF Program, *Country Activity Index Report, Corporate Patenting 1995*, report prepared for the National Science Foundation (Washington, DC: 1996).

See text table 6-6.

Appendix table 6-14.

Patent classes most emphasized by inventors from Japan patenting in the United States: 1985 and 1995

Patent class number and title		Patents granted to inventors from:				Activity index	
		All countries		Japan			
		1985	1995	1985	1995	1985	1995
369	Dynamic information storage or retrieval	277	658	158	508	2.671	3.003
354	Photography	355	471	245	332	3.232	2.742
084	Music	101	220	63	151	2.921	2.670
355	Photocopying	422	753	213	489	2.364	2.526
358	Facsimile or television recording	248	629	169	395	3.191	2.443
400	Typewriting machines	212	206	86	118	1.900	2.228
365	Static information storage and retrieval	228	897	95	489	1.951	2.121
360	Dynamic magnetic information storage or retrieval	476	789	271	411	2.666	2.026
257	Active solid-state devices (e.g., transistors, solid-state diodes)	294	1,308	107	675	1.704	2.008
430	Radiation imagery chemistry: process, composition, or products	745	1,421	392	732	2.464	2.004
347	Incremental printing of symbolic information	320	486	184	247	2.693	1.977
359	Optics: systems (including communication) and element	549	1083	198	521	1.689	1.871
310	Electrical generator or motor structure	307	386	104	175	1.586	1.764
348	Television	569	1028	179	461	1.473	1.744
148	Metal treatment	225	352	68	156	1.415	1.724
345	Selective visual display systems	159	356	48	146	1.414	1.595
271	Sheet feeding or delivering	174	247	54	101	1.453	1.591
372	Coherent light generators	127	364	27	140	0.996	1.496
118	Coating apparatus	208	288	53	107	1.193	1.445
382	Image analysis	120	323	43	120	1.678	1.445
242	Winding, tensioning, or guiding	367	310	118	113	1.506	1.418
318	Electricity: motive power systems	361	371	120	134	1.557	1.405
123	Internal-combustion engines	1,103	727	558	260	2.369	1.391
333	Wave transmission lines and networks	167	213	29	75	0.813	1.370
364	Electrical computers and data processing systems	695	1,529	221	512	1.489	1.303
428	Stock material or miscellaneous articles	1,280	1,890	382	630	1.397	1.297
371	Error detection/correction and fault detection/recovery	142	431	28	141	0.923	1.273
425	Plastic article or earthenware shaping or treating	263	290	33	92	0.588	1.234
437	Semiconductor device manufacturing: process	380	1362	106	431	1.306	1.231
363	Electric power conversion systems	130	206	28	65	1.009	1.227
501	Compositions: ceramic	142	215	47	67	1.550	1.212
313	Electric lamp and discharge devices	221	282	50	87	1.059	1.200
303	Fluid-pressure and analogous brake systems	78	202	24	62	1.441	1.194
327	Miscellaneous active electrical nonlinear devices	302	627	88	192	1.364	1.191
356	Optics: measuring and testing	340	669	79	200	1.088	1.163
455	Telecommunications	158	403	40	120	1.185	1.158
523	Synthetic resins or natural rubbers—part of the class 520 series	277	210	58	62	0.980	1.149
429	Chemistry: electrical current producing apparatus, product and process	221	387	47	114	0.996	1.146
250	Radiant energy	538	993	149	287	1.297	1.124
395	Information processing system organization	550	3,025	131	871	1.115	1.120
341	Coded data generation or conversion	170	280	52	79	1.432	1.098
381	Electrical audio signal processing systems and devices	141	217	46	61	1.528	1.094
526	Synthetic resins or natural rubbers—part of the class 520 series	284	363	80	101	1.319	1.082
074	Machine element or mechanism	365	290	121	80	1.552	1.073
417	Pumps	306	237	64	65	0.979	1.067
525	Synthetic resins or natural rubbers—part of the class 520 series	551	726	132	199	1.122	1.066
439	Electrical connectors	496	810	38	219	0.359	1.052
060	Power plants	380	547	85	147	1.047	1.045
101	Printing	197	269	29	72	0.689	1.041
524	Synthetic resins or natural rubbers—part of the class 520 series	664	725	98	194	0.691	1.041
219	Electric heating	627	527	191	139	1.426	1.026

NOTES: The activity index is the percentage of the patents in a class that are granted to inventors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to U.S. Patent and Trademark Office classes that received at least 200 patents from all countries in 1995.

SOURCE: U.S. Patent and Trademark Office, Office of Information Systems, TAF Program, *Country Activity Index Report, Corporate Patenting 1995*, report prepared for the National Science Foundation (Washington, DC: 1996).

See text table 6-6.

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Appendix table 6-15.

Patent classes most emphasized by inventors from Germany patenting in the United States: 1985 and 1995

	Patents granted to inventors from:					
	All countries		Germany		Activity index	
Patent class number and title	1985	1995	1985	1995	1985	1995
303 Fluid-pressure and analogous brake systems	78	202	21	68	2.577	4.576
101 Printing	197	269	52	90	2.526	4.548
188 Brakes	182	223	23	61	1.210	3.719
198 Conveyors: power-driven	233	271	27	51	1.109	2.558
548 Organic compounds—part of the class 532–570 series	212	281	41	52	1.851	2.516
072 Metal deforming	299	235	34	41	1.088	2.372
546 Organic compounds—part of the class 532–570 series	209	232	23	40	1.053	2.344
123 Internal-combustion engines	1,103	727	167	123	1.449	2.300
271 Sheet feeding or delivering	174	247	22	38	1.210	2.091
378 X-ray or gamma ray systems or devices	122	234	27	35	2.118	2.033
425 Plastic article or earthenware shaping or treating	263	290	42	43	1.528	2.016
568 Organic compounds—part of the class 532-570 series	365	302	44	43	1.154	1.936
549 Organic compounds—part of the class 532-570 series	214	235	31	33	1.386	1.909
074 Machine element or mechanism	365	290	40	40	1.049	1.875
528 Synthetic resins or natural rubbers—part of the class 520 series	411	531	58	69	1.351	1.767
524 Synthetic resins or natural rubbers—part of the class 520 series	664	725	85	94	1.225	1.763
451 Abrading	195	209	25	27	1.227	1.756
242 Winding, tensioning, or guiding	367	310	60	40	1.565	1.754
423 Chemistry of inorganic compounds	590	390	85	49	1.379	1.708
525 Synthetic resins or natural rubbers—part of the class 520 series	551	726	51	87	0.886	1.629
252 Compositions	785	1,039	73	119	0.890	1.557
248 Supports	211	247	23	28	1.043	1.541
204 Chemistry: electrical and wave energy	326	426	21	45	0.617	1.436
417 Pumps	306	237	43	25	1.345	1.434
073 Measuring and testing	938	1,100	109	115	1.112	1.421
422 Chemical apparatus and process disinfecting, deodorizing, preserving, or sterilizing	211	526	27	55	1.225	1.421
106 Compositions: coating or plastic	207	393	36	41	1.664	1.418
297 Chairs and seats	154	223	27	23	1.678	1.402
222 Dispensing	249	339	21	34	0.807	1.363
239 Fluid sprinkling, spraying, and diffusing	230	240	23	24	0.957	1.359
075 Specialized metallurgical processes, compositions for	190	212	21	21	1.058	1.347
414 Material or article handling	316	324	32	32	0.969	1.343
205 Electrolysis: processes, compositions used therein	301	266	31	26	0.986	1.329
526 Synthetic resins or natural rubbers—part of the class 520 series	284	363	19	35	0.640	1.311
342 Communications: directive radio wave systems and devices	109	274	12	26	1.054	1.290
053 Package making	289	351	31	32	1.027	1.239
523 Synthetic resins or natural rubbers—part of the class 520 series	277	210	30	19	1.037	1.230
514 Drug, bio-affecting and body treating compositions	1,564	2,360	196	209	1.199	1.204
501 Compositions: ceramic	142	215	13	19	0.876	1.201
363 Electric power conversion systems	130	206	8	18	0.589	1.188
162 Paper making and fiber liberation	163	208	16	18	0.939	1.176
502 Catalyst, solid sorbent, or support therefor: product	425	302	20	26	0.450	1.170
310 Electrical generator or motor structure	307	386	36	33	1.122	1.162
210 Liquid purification or separation	452	782	43	66	0.911	1.147
137 Fluid handling	531	427	56	36	1.009	1.146
060 Power plants	380	547	44	46	1.108	1.143
118 Coating apparatus	208	288	26	24	1.196	1.133
015 Brushing, scrubbing, and general cleaning	135	229	21	19	1.489	1.128
280 Land vehicles	285	581	32	48	1.075	1.123
427 Coating processes	555	691	62	57	1.069	1.121
219 Electric heating	627	527	45	43	0.687	1.109
536 Organic compounds—part of the class 532–570 series	95	320	15	26	1.511	1.105

NOTES: The activity index is the percentage of the patents in a class that are granted to inventors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to U.S. Patent and Trademark Office classes that received at least 200 patents from all countries in 1995.

SOURCE: U.S. Patent and Trademark Office, Office of Information Systems, TAF Program, *Country Activity Index Report, Corporate Patenting 1995*, report prepared for the National Science Foundation (Washington, DC: 1996).

See text table 6-6.

Appendix table 6-16.
Patent classes most emphasized by inventors from Taiwan patenting in the United States: 1985 and 1995

Patent class number and title		Patents granted to inventors from:				Activity index	
		All countries		Taiwan			
		1985	1995	1985	1995	1985	1995
437	Semiconductor device manufacturing: process	380	1,362	0	152	0.000	15.159
345	Selective visual display systems	159	356	0	10	0.000	3.816
074	Machine element or mechanism	365	290	0	8	0.000	3.747
297	Chairs and seats	154	223	0	6	0.000	3.655
313	Electric lamp and discharge devices	221	282	0	6	0.000	2.890
257	Active solid-state devices (e.g., transistors, solid-state diodes)	294	1,308	0	27	0.000	2.804
327	Miscellaneous active electrical nonlinear devices	302	627	0	12	0.000	2.600
362	Illumination	171	330	0	6	0.000	2.470
425	Plastic article or earthenware shaping or treating	263	290	0	5	0.000	2.342
248	Supports	211	247	0	4	0.000	2.200
200	Electricity: circuit makers and breakers	273	207	0	3	0.000	1.969
333	Wave transmission lines and networks	167	213	0	3	0.000	1.913
280	Land vehicles	285	581	0	8	0.000	1.870
084	Music	101	220	0	3	0.000	1.852
365	Static information storage and retrieval	228	897	0	12	0.000	1.817
375	Pulse or digital communications	177	573	0	7	0.000	1.659
385	Optical waveguides	178	504	0	6	0.000	1.617
439	Electrical connectors	496	810	0	9	0.000	1.509
156	Adhesive bonding and miscellaneous chemical manufacture	546	779	0	8	0.000	1.395
264	Plastic and nonmetallic article shaping or treating: process	493	693	0	7	0.000	1.372
568	Organic compounds—part of the class 532-570 series	365	302	0	3	0.000	1.349
206	Special receptacle or package	262	404	0	4	0.000	1.345
400	Typewriting machines	212	206	0	2	0.000	1.319
075	Specialized metallurgical processes, compositions for	190	212	0	2	0.000	1.281
501	Compositions: ceramic	142	215	0	2	0.000	1.264
382	Image analysis	120	323	0	3	0.000	1.262
273	Amusement devices: games	108	331	0	3	0.000	1.231
188	Brakes	182	223	0	2	0.000	1.218
015	Brushing, scrubbing, and general cleaning	135	229	0	2	0.000	1.186
427	Coating processes	555	691	0	6	0.000	1.179
072	Metal deforming	299	235	0	2	0.000	1.156
330	Amplifiers	247	241	0	2	0.000	1.127
372	Coherent light generators	127	364	0	3	0.000	1.120
271	Sheet feeding or delivering	174	247	0	2	0.000	1.100
429	Chemistry: electrical current producing apparatus, product, and process	221	387	0	3	0.000	1.053
423	Chemistry of inorganic compounds	590	390	1	3	6.917	1.045
205	Electrolysis: processes, compositions used therein	301	266	0	2	0.000	1.021
364	Electrical computers and data processing systems	695	1,529	0	11	0.000	0.977
029	Metal working	604	699	0	5	0.000	0.972
341	Coded data generation or conversion	170	280	0	2	0.000	0.970
204	Chemistry: electrical and wave energy	326	426	0	3	0.000	0.957
371	Error detection/correction and fault detection/recovery	142	431	0	3	0.000	0.945
524	Synthetic resins or natural rubbers—part of the class 520 series	664	725	0	5	0.000	0.937
359	Optics: systems (including communication) and element	549	1,083	0	7	0.000	0.878
052	Static structures (e.g., buildings)	313	315	0	2	0.000	0.862
370	Multiplex communications	276	800	0	5	0.000	0.849
326	Electronic digital logic circuitry	115	333	0	2	0.000	0.816
053	Package making	289	351	0	2	0.000	0.774
219	Electric heating	627	527	0	3	0.000	0.773
148	Metal treatment	225	352	0	2	0.000	0.772
528	Synthetic resins or natural rubbers—part of the class 520 series	411	531	0	3	0.000	0.767

NOTES: The activity index is the percentage of the patents in a class that are granted to inventors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to U.S. Patent and Trademark Office classes that received at least 200 patents from all countries in 1995.

SOURCE: U.S. Patent and Trademark Office, Office of Information Systems, TAF Program, *Country Activity Index Report, Corporate Patenting 1995*, report prepared for the National Science Foundation (Washington, DC: 1996).

See text table 6-7.

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Appendix table 6-17.

Patent classes most emphasized by inventors from South Korea patenting in the United States: 1985 and 1995

		Patents granted to inventors from:					
		All countries		South Korea		Activity index	
Patent class number and title		1985	1995	1985	1995	1985	1995
313	Electric lamp and discharge devices	221	282	0	27	0.000	7.550
437	Semiconductor device manufacturing: process	380	1,362	0	123	0.000	7.122
348	Television	569	1,028	0	85	0.000	6.520
358	Facsimile or television recording	248	629	0	42	0.000	5.266
369	Dynamic information storage or retrieval	277	658	0	39	0.000	4.674
360	Dynamic magnetic information storage or retrieval	476	789	0	46	0.000	4.598
365	Static information storage and retrieval	228	897	0	44	0.000	3.868
242	Winding, tensioning, or guiding	367	310	0	13	0.000	3.307
219	Electric heating	627	527	0	22	0.000	3.292
371	Error detection/correction and fault detection/recovery	142	431	0	16	0.000	2.927
315	Electric lamp and discharge devices: systems	236	332	0	12	0.000	2.850
318	Electricity: motive power systems	361	371	0	13	0.000	2.763
381	Electrical audio signal processing systems and devices	141	217	0	7	0.000	2.544
257	Active solid-state devices (e.g., transistors, solid-state diodes)	294	1,308	0	38	0.000	2.291
341	Coded data generation or conversion	170	280	0	8	0.000	2.253
015	Brushing, scrubbing, and general cleaning	135	229	0	6	0.000	2.066
062	Refrigeration	423	515	0	13	0.000	1.991
340	Communications: electrical	381	598	0	15	0.000	1.978
327	Miscellaneous active electrical nonlinear devices	302	627	0	15	0.000	1.887
501	Compositions: ceramic	142	215	0	5	0.000	1.834
326	Electronic digital logic circuitry	115	333	0	7	0.000	1.658
400	Typewriting machines	212	206	0	4	0.000	1.531
528	Synthetic resins or natural rubbers—part of the class 520 series	411	531	1	10	8.178	1.485
355	Photocopying	422	753	0	14	0.000	1.466
084	Music	101	220	0	4	0.000	1.434
548	Organic compounds—part of the class 532-570 series	212	281	0	5	0.000	1.403
359	Optics: systems (including communication) and element	549	1,083	0	19	0.000	1.383
280	Land vehicles	285	581	0	9	0.000	1.222
380	Cryptography	47	204	0	3	0.000	1.160
347	Incremental printing of symbolic information	320	486	0	7	0.000	1.136
523	Synthetic resins or natural rubbers—part of the class 520 series	277	210	0	3	0.000	1.127
148	Metal treatment	225	352	0	5	0.000	1.120
345	Selective visual display systems	159	356	0	5	0.000	1.108
375	Pulse or digital communications	177	573	0	8	0.000	1.101
427	Coating processes	555	691	0	9	0.000	1.027
156	Adhesive bonding and miscellaneous chemical manufacture	546	779	0	10	0.000	1.012
524	Synthetic resins or natural rubbers—part of the class 520 series	664	725	0	9	0.000	0.979
372	Coherent light generators	127	364	0	4	0.000	0.867
361	Electricity: electrical systems and devices	463	763	0	8	0.000	0.827
333	Wave transmission lines and networks	167	213	0	2	0.000	0.740
134	Cleaning and liquid contact with solids	84	224	0	2	0.000	0.704
546	Organic compounds—part of the class 532-570 series	209	232	0	2	0.000	0.680
549	Organic compounds—part of the class 532-570 series	214	235	0	2	0.000	0.671
354	Photography	355	471	0	4	0.000	0.670
364	Electrical computers and data processing systems	695	1,529	0	13	0.000	0.670
239	Fluid sprinkling, spraying, and diffusing	230	240	0	2	0.000	0.657
330	Amplifiers	247	241	0	2	0.000	0.654
525	Synthetic resins or natural rubbers—part of the class 520 series	551	726	0	6	0.000	0.652
271	Sheet feeding or delivering	174	247	0	2	0.000	0.639
422	Chemical apparatus and process disinfecting, deodorizing, preserving, or sterilizing	211	526	0	4	0.000	0.600
356	Optics: measuring and testing	340	669	0	5	0.000	0.589
455	Telecommunications	158	403	0	3	0.000	0.587

NOTES: The activity index is the percentage of the patents in a class that are granted to inventors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to U.S. Patent and Trademark Office classes that received at least 200 patents from all countries in 1995.

SOURCE: U.S. Patent and Trademark Office, Office of Information Systems, TAF Program, *Country Activity Index Report, Corporate Patenting 1995*, report prepared for the National Science Foundation (Washington, DC: 1996).

See text table 6-7.

Appendix table 6-18.

Patents granted in selected countries, by inventor residence: 1985-95

Granting country	Total patents	Patents to non-residents as percentage of total	Percentage of patents granted to residents of:									
			United States	Japan	Germany	France	United Kingdom	Italy	Sweden	India	Former Soviet Union	Other
1985												
Japan	50,100	15.5	46.4	0.0	19.6	6.4	5.4	1.5	2.3	0.0	1.4	17.0
Germany	33,377	60.4	29.2	23.9	0.0	12.4	6.7	2.8	2.8	0.0	1.7	20.5
France	37,530	73.8	27.4	15.8	25.9	0.0	5.9	4.1	2.4	0.0	1.3	17.0
United Kingdom	34,480	82.3	28.6	20.8	20.9	8.4	0.0	2.9	2.2	0.0	0.6	15.6
Italy	47,924	79.0	6.1	2.3	8.0	4.2	2.0	0.0	0.4	0.0	0.0	77.0
Canada	18,697	92.8	54.8	11.7	8.8	5.6	5.3	1.5	1.8	0.0	0.4	10.0
Mexico	1,374	93.4	56.3	6.6	7.6	7.0	4.0	2.6	1.5	0.0	0.5	14.0
Brazil	3,934	84.6	37.0	7.3	20.7	9.9	4.0	4.6	2.8	0.0	0.4	13.3
South Korea	2,268	84.6	30.4	42.3	6.2	5.4	3.5	1.8	1.4	0.0	0.0	9.1
Soviet Union	74,745	2.0	13.7	8.4	16.9	8.2	3.1	3.9	2.7	0.0	0.0	42.9
India	1,814	76.2	33.5	6.4	11.2	8.1	10.1	3.4	1.3	0.0	3.0	23.0
1990												
Japan	59,401	15.2	45.5	0.0	21.3	7.7	5.1	2.4	2.4	0.0	1.1	14.4
Germany	42,860	61.2	27.8	28.4	0.0	10.8	6.5	3.7	2.7	0.0	0.7	19.3
France	35,149	74.6	24.9	18.2	26.9	0.0	6.0	4.2	2.2	0.0	0.6	17.0
United Kingdom	32,179	86.4	25.6	20.8	22.8	9.1	0.0	3.2	2.0	0.0	0.4	15.9
Italy	17,794	98.7	23.7	9.4	28.5	12.4	6.8	0.0	2.4	0.0	0.1	16.7
Canada	14,187	92.2	52.2	13.7	8.3	6.0	5.4	2.0	1.8	0.0	0.3	10.3
Mexico	1,752	92.0	63.4	5.4	7.3	5.1	3.2	2.4	0.8	0.1	0.2	12.2
Brazil	3,355	86.5	41.4	6.6	16.1	9.4	7.4	4.4	2.3	0.0	0.7	11.8
South Korea	7,762	67.1	23.0	66.7	2.5	1.8	0.8	1.1	0.3	0.0	0.0	3.8
Soviet Union	84,658	1.4	12.0	8.1	18.8	7.8	3.6	6.7	3.8	0.0	0.0	39.2
India	1,611	81.0	35.3	9.3	14.6	6.2	7.8	3.1	1.2	0.0	3.4	19.1
1994												
Japan	82,400	11.7	50.1	0.0	18.9	6.5	4.1	2.5	1.8	0.0	0.0	16.3
Germany	57,803	64.1	28.2	32.5	0.0	9.8	5.9	4.0	2.0	0.0	0.0	17.4
France	54,964	75.3	25.0	23.5	25.5	0.0	5.3	3.9	1.6	0.0	0.0	15.2
United Kingdom	48,772	89.3	24.9	25.7	22.0	8.0	0.0	3.3	1.5	0.0	0.0	14.5
Italy	37,096	85.5	24.8	13.4	27.6	10.2	5.9	0.0	1.9	0.0	0.1	16.1
Canada	11,641	92.7	51.3	18.8	7.6	5.6	4.6	1.5	1.0	0.0	0.0	9.5
Mexico	4,367	93.4	58.0	4.3	9.7	5.1	4.3	2.4	1.1	0.0	0.0	14.9
Brazil	2,469	83.0	41.3	6.6	12.5	6.9	4.9	6.4	2.7	0.0	0.0	18.7
South Korea	11,683	50.6	22.9	62.6	3.9	2.5	1.1	0.8	0.5	0.0	0.0	5.8
Russian Federation	20,581	22.0	4.0	2.1	4.7	1.1	0.8	1.5	0.6	0.0	0.0	85.2
India	1,735	74.2	42.9	6.1	12.4	7.1	6.6	2.6	1.6	0.0	0.2	20.4

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Appendix table 6-18.
Patents granted in selected countries, by inventor residence: 1985-95

Granting country	Total patents	Patents to non-residents as percentage of total	Percentage of patents granted to residents of:									
			United States	Japan	Germany	France	United Kingdom	Italy	Sweden	India	Former Soviet Union	Other
			1995									
Japan	109,100	13.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Germany	56,633	65.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
France	55,681	72.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
United Kingdom	48,350	89.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Italy	29,898	97.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Canada	9,139	91.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mexico	3,538	95.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Brazil	2,659	80.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
South Korea	12,512	47.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Russian Federation	25,633	18.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
India	1,613	74.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = not available

NOTE: German data are for the former West Germany only.

SOURCE: World Intellectual Property Organization, "Industrial Property Statistics" (Geneva: 1985-95).

See figures 6-18 and 6-19.

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Appendix table 6-19.

Venture capital under management in the United States and disbursements: 1969-95

(Millions of U.S. dollars)

	New capital committed	Total venture capital under management	Disbursements
1969	121	NA	100
1970	78	NA	83
1971	91	NA	134
1972	30	NA	128
1973	33	NA	201
1974	25	NA	100
1975	20	NA	92
1976	28	NA	107
1977	15	NA	159
1978	216	NA	288
1979	170	NA	457
1980	661	NA	608
1981	867	NA	1,155
1982	1,400	NA	1,454
1983	3,400	6,208	2,581
1984	3,200	9,497	2,771
1985	2,300	11,614	2,681
1986	3,300	14,693	3,242
1987	4,200	17,799	3,977
1988	2,947	20,217	3,847
1989	2,399	23,154	3,395
1990	1,847	24,139	1,922
1991	1,271	24,758	1,348
1992	2,548	25,868	2,540
1993	2,545	28,925	3,071
1994	3,765	32,670	2,741
1995	4,227	37,154	3,859

NA = not available

SOURCE: Venture Economics, *1996 Venture Capital Annual Review* (Boston: 1996).

See figure 6-23. *Science & Engineering Indicators – 1998*

Appendix table 6-20.

Capital commitments by limited partners to institutionally funded independent private venture capital funds: 1978-95

(Millions of U.S. dollars)

	Total	Corporations	Endowments & foundations	Foreign investors	Individuals & families	Insurance companies	Pension funds
1978	216	22	19	38	70	35	32
1979	170	28	17	26	39	7	53
1980	661	127	92	55	102	88	197
1981	867	142	102	90	201	132	200
1982	1,423	175	96	188	290	200	474
1983	3,408	415	267	531	715	410	1,070
1984	3,185	463	178	573	467	419	1,085
1985	2,327	274	181	548	303	254	767
1986	3,332	350	209	361	392	348	1,672
1987	4,184	460	418	544	502	628	1,632
1988	2,947	324	341	401	249	277	1,355
1989	2,399	483	296	299	146	303	872
1990	1,847	125	232	138	211	171	970
1991	1,271	55	306	149	156	69	536
1992	2,548	84	471	283	280	370	1,060
1993	2,545	206	271	109	187	268	1,504
1994	3,765	341	805	91	444	357	1,727
1995	4,227	87	959	NA	741	784	1,656

SOURCE: Venture Economics, *1996 Venture Capital Annual Review* (Boston: 1996).

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Appendix table 6-21.

U.S. venture capital disbursements, by industry category: 1986-95

Industry category	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Millions of U.S. dollars disbursed										
Commercial communications	145	171	105	146	80	20	53	134	46	191
Telephone and data communications	346	306	369	342	268	169	366	384	294	399
Computer hardware and systems	550	523	422	354	259	168	138	98	171	183
Software and services	353	417	338	379	362	337	562	630	378	760
Other electronics	386	361	319	300	147	129	140	86	167	141
Biotechnology	183	265	322	245	181	112	261	283	303	205
Medical/health care related	335	481	451	522	380	152	442	437	473	547
Energy related	23	53	15	18	22	3	30	7	2	3
Industrial automation	73	55	31	28	16	3	7	30	16	26
Industrial products and machinery	118	183	198	192	77	47	77	54	56	125
Consumer related	285	642	425	392	225	135	196	314	173	405
Other products and services	445	520	852	477	284	83	271	613	663	874
Total	3,242	3,977	3,847	3,395	2,301	1,358	2,543	3,071	2,741	3,859
Percentage of total venture capital disbursements										
Commercial communications	4	4	3	4	3	2	2	4	2	5
Telephone and data communications	10	8	9	10	12	12	14	13	11	10
Computer hardware and systems	17	13	11	10	11	12	5	3	6	5
Software and services	11	11	9	11	16	25	22	21	14	20
Other electronics	12	9	8	9	6	9	6	3	6	4
Biotechnology	6	7	8	7	8	8	10	9	11	5
Medical/health care related	10	12	12	15	17	11	17	14	17	14
Energy related	1	1	1	1	1	1	1	<1	<1	<1
Industrial automation	2	1	1	1	1	1	1	1	<1	<1
Industrial products and machinery	4	5	5	6	3	3	3	2	2	3
Consumer related	9	16	11	12	10	10	8	10	6	11
Other products and services	14	13	22	14	12	6	11	20	24	23
Total	100	100	100	100	100	100	100	100	100	100

NOTE: Details may not sum to totals because of rounding.

SOURCE: Venture Economics, *1996 Venture Capital Annual Review* (Boston: 1996).

See figure 6-24.

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Appendix table 6-22.
U.S. venture capital disbursements, by stage: 1986-95

Stage	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Millions of U.S. dollars disbursed										
Seed	101	87	114	138	72	56	74	213	116	232
Startup	526	452	349	288	170	76	209	217	408	663
Other early stage	509	603	585	537	391	295	336	319	481	580
Expansion	1,416	1,773	1,510	1,596	1,194	734	1,400	1,668	1,232	1,614
Leveraged buyout/acquisition	601	804	1,127	710	414	46	176	172	166	338
Other	89	258	162	126	60	151	347	481	339	432
Total disbursements	3,242	3,977	3,847	3,395	2,301	1,358	2,542	3,070	2,741	3,859
Percentage of total venture capital disbursements										
Seed	3	2	3	4	3	4	3	7	4	6
Startup	16	11	9	8	7	6	8	7	15	17
Other early stage	16	15	15	16	17	22	13	10	18	15
Expansion	44	45	40	47	52	54	55	54	45	42
Leveraged buyout/acquisition	18	20	29	21	18	3	7	6	0	9
Other	3	7	4	4	3	11	14	16	12	11
Total	100	100	100	100	100	100	100	100	100	100

NOTE: Details may not sum to totals because of rounding.

SOURCE: Venture Economics, *1996 Venture Capital Annual Review* (Boston: 1996).

See figure 6-25.

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Appendix table 6-23.
Leading indicators of technological competitiveness: 1996
(Index)

Region/country	National orientation	Socioeconomic infrastructure	Technological infrastructure	Productive capacity
Singapore	88.4	75.7	41.6	54.0
South Korea	78.9	64.6	44.4	50.6
Taiwan	90.2	75.8	42.9	49.9
China	65.3	44.8	39.3	32.8
India	57.4	46.0	39.3	49.1
Indonesia	54.8	35.2	17.8	19.6
Malaysia	81.0	62.5	31.9	43.1
Philippines	73.6	66.2	35.3	48.1
Thailand	63.5	48.7	28.2	33.1
Hungary	67.0	47.7	36.4	39.8
Poland	69.7	57.4	38.1	39.8
Russia	48.9	50.7	55.6	42.6
Argentina	41.5	49.4	27.4	31.0
Brazil	60.0	53.1	37.4	40.3
Mexico	54.8	45.5	30.2	31.7
Venezuela	56.6	55.2	38.4	40.7
South Africa	49.2	51.0	40.3	30.0

NOTES: For score and indicator calculations, raw data were transformed into scales of 0-100 for each indicator component and then averaged to generate comparable indicators with a 0-100 range. For survey items, 100 represents the highest response category for each question; for statistical data, 100 typically represents the value attained by the country with the largest value among the 30 countries included in the study. In the indicator formulations cited below, each term carries equal weight.

National orientation (NO)—evidence that a nation is taking directed action to achieve technological competitiveness. These actions could take place in the business, government, or cultural sector, or any combination of the three.
Indicator formulation: NO = Q1 + (Q2 + Q3)/2 + Q4 + F1V96
Data used: Published data from Frost and Sullivan's "Political Risk Letter" for 1996 rating each country's investment risk (F1V96); and survey data assessing each country's national strategy to promote high-tech development (Q1), social influences favoring technological change (Q2 and Q3), and entrepreneurial spirit (Q4).

Socioeconomic infrastructure (SE)—assesses the social and economic institutions that support and maintain the physical, human, organizational, and economic resources essential to the functioning of a modern, technology-based industrial nation.
Indicator formulation: SE = Q5 + Q10 + HMHS93
Data used: Published data on the percentage of students enrolled in secondary and tertiary education (HMHS93) from the Harbison-Myers Skills Index for 1993; and survey data assessing each country's efforts to attract foreign investment (Q10) and the mobility of capital (Q5).

Technological infrastructure (TI)—assesses the institutions and resources that contribute to a nation's capacity to develop, produce, and market new technology.
Indicator formulation: TI = (Q7 + Q8)/2 + Q9 + Q11 + EDP96 + S&E
Data used: Published data from UN Statistical Yearbook on the number of scientists and engineers involved in research (S&E), national purchases of electronic data processing equipment (EDP96) from *Elsevier Yearbook of World Electronics Data* (1996); and survey data assessing linkages of R&D to industry (Q9), output of indigenous academic science and engineering (Q7and Q8), and ability to make effective use of technological knowledge (Q11).

Productive capacity (PC)—assesses the phsical and human resources devoted to manufacturing products and the efficiency with which those resources are employed.
Indicator formulation: PC = Q6 + Q12 + Q13 + A2696
Data used: Published data on electronics production (A2696) from *Elsevier Yearbook of World Electronics Data* (1996); and survey data assessing the supply and quality of skilled labor (Q6), capability of the indigenous management (Q13), and the existence of indigenous suppliers of components for technology-intensive products (Q12).

SOURCE: J. David Roessner, Alan L. Porter, Nils Newman, and Honguang Xu, *1996 Indicators of Technology-Based Competitiveness of Nations, Summary Report*, report to the National Science Foundation under Purchase Order No. D22588X-00-0 (Atlanta: Georgia Institute of Technology, 1997).

See figure 6-27.

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Appendix table 7-1.
Indices of issue interest: 1979-97
(Mean index scores)

Issue	1979	1981	1983	1985	1988	1990	1992	1995	1997
Foreign policy	49	59	54	59	58	68	62	48	47
New scientific discoveries	61	60	68	66	66	63	61	67	70
New technologies	59	58	65	64	64	64	64	66	69
Space exploration	–	47	50	52	56	50	47	50	55
Energy/nuclear power[a]	67	70	62	61	61	64	57	54	54
Medical discoveries	–	–	–	83	85	83	82	83	83
Environmental issues	–	–	–	–	–	80	77	74	72
Economic policy	59	71	74	69	69	70	74	68	68
Sample size	1,635	3,195	1,631	2,005	2,041	2,033	2,001	2,006	2,000

– = not asked

NOTES: Each index is a summary measure of respondent reports that they are "very interested," "moderately interested," or "not at all interested" in each specific issue. Responses are to the statement: "There are a lot of issues in the news, and it is hard to keep up with every area. I'm going to read to you a short list of issues, and for each one—as I read it—I would like you to tell me if you are very interested, moderately interested, or not at all interested." The original responses were converted to a 0-100 index by assigning a value of 100 for a "very interested" response and a value of 50 for a "moderately interested" response.

[a] In 1990, 1992, 1995, and 1997 the question was worded "...issues about the use of nuclear energy to generate electricity." From 1979 to 1985, the question was worded "...issues about energy policy." In 1988, the question was worded "...issues about the use of nuclear power to generate electricity."

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

See figure 7-1.

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Appendix table 7-2.
Public interest in selected issues: 1979-97
(Percentages)

Issue	1979			1981			1983			1985			1988			1990			1992			1995			1997		
	VI	MI	NI	VI	MI	NI	VI	MI	NI	VI	MI	NI	VI	MI	NI	VI	MI	NI	VI	MI	NI	VI	MI	NI	VI	MI	NI
Foreign policy	22	53	24	35	47	18	30	47	22	33	51	16	33	50	16	48	40	12	38	47	15	21	53	26	22	50	28
New scientific discoveries	36	49	14	37	45	17	48	40	11	44	44	12	43	46	12	39	48	12	36	49	15	44	45	11	49	42	8
New technologies	33	51	15	33	50	16	42	45	12	39	49	12	40	48	12	39	49	12	37	53	10	43	46	27	47	43	10
Space exploration	–	–	–	25	44	31	27	45	28	29	46	25	34	44	22	26	48	26	22	50	28	25	49	26	32	45	22
Energy/nuclear power[a]	46	42	11	50	40	10	39	46	14	36	50	13	38	46	16	42	44	14	32	49	18	29	49	21	29	49	21
Medical discoveries	–	–	–	–	–	–	–	–	–	68	29	3	72	25	3	68	29	3	66	31	3	69	27	4	70	26	4
Environmental issues	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	64	31	5	59	36	5	53	41	6	52	40	8
Economic policy	35	48	17	52	37	10	57	33	10	48	41	11	48	42	10	50	40	10	56	36	8	47	42	11	47	42	11
Sample size		1,635			3,195			1,631			2,005			2,041			2,033			2,001			2,006			2,000	

VI = very interested; MI = moderately interested; NI = not at all interested; – = not asked

NOTES: Responses are to the statement: "There are a lot of issues in the news, and it is hard to keep up with every area. I'm going to read to you a short list of issues, and for each one—as I read it—I would like you to tell me if you are very interested, moderately interested, or not at all interested." "Don't know" responses are not included. Percentages may not total 100 because of rounding.

[a] In 1990, 1992, 1995, and 1997 the question was worded "…issues about the use of nuclear energy to generate electricity." From 1979 to 1985, the question was worded "…issues about energy policy." In 1988, the question was worded "…issues about the use of nuclear power to generate electricity."

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

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Appendix table 7-3.

Mean score on indices of interest in scientific and technological issues, by sex and level of education: 1997

(Mean index scores)

Sex and level of education	New scientific discoveries	New technologies	Medical discoveries	Space exploration	Nuclear energy	Environmental issues	Sample size
All adults	70	69	83	55	54	72	2,000
Sex							
Male	71	73	81	63	55	70	930
Female	70	65	86	49	54	75	1,070
Formal education							
Less than high school	61	56	79	42	54	70	420
High school graduate	70	70	85	56	53	73	1,188
Baccalaureate degree	78	75	86	66	58	74	257
Graduate/professional degree	84	80	87	67	62	79	135
Science/mathematics education[a]							
Low	64	62	83	48	51	71	1,112
Middle	75	73	85	58	57	74	509
High	84	81	85	72	61	74	379

NOTES: Each index is a summary measure of respondent reports that they are "very interested," "moderately interested," or "not at all interested" in each specific issue. A value of 100 was assigned to a "very interested" response, and a value of 50 was assigned to a "moderately interested" response.

[a]Respondents were classified as having a "high" level of science/mathematics education if they took nine or more high school and college science/math courses. They were classified as "middle" if they took six to eight such courses, and as "low" if they took five or fewer.

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997), and unpublished tabulations.

See figure 7-2.

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Appendix table 7-4.

Indices of issue informedness: 1979-97

(Mean index scores)

Issue	1979	1981	1983	1985	1988	1990	1992	1995	1997
Foreign policy	35	44	40	42	42	51	46	36	36
New scientific discoveries	36	38	40	43	42	42	39	42	49
New technologies	35	35	42	39	38	38	38	40	44
Space exploration	–	37	39	42	39	37	33	33	41
Energy/nuclear power[a]	47	51	47	44	37	37	32	29	31
Medical discoveries	–	–	–	53	52	53	51	52	56
Environmental issues	–	–	–	–	–	60	57	52	51
Economic policy	42	55	54	48	50	53	56	52	51
Sample size	1,635	3,195	1,631	2,005	2,041	2,033	2,001	2,006	2,000

– = not asked

NOTES: Each index is a summary measure of respondent reports that they are "very well-informed," "moderately well-informed," or "poorly informed" about each specific issue. Responses are to the statement: "Now I'd like to go through this list with you again, and for each issue I'd like you to tell me if you are very well-informed, moderately well-informed, or poorly informed." The original responses were converted to a 0-100 index by assigning a value of 100 for a "very well-informed" response and a value of 50 for a "moderately well-informed" response.

[a] In 1990, 1992, 1995, and 1997 the question was worded "...issues about the use of nuclear energy to generate electricity." From 1979 to 1985, the question was worded "...issues about energy policy." In 1988, the question was worded "...issues about the use of nuclear power to generate electricity."

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy. 1997); and unpublished tabulations.

See figure 7-3.

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Appendix table 7-5.

Public informedness on selected issues: 1979-97

(Percentages)

Issue	1979			1981			1983			1985			1988			1990			1992			1995			1997		
	VI	MI	NI	VI	MI	NI	VI	MI	NI	VI	MI	NI	VI	MI	NI	VI	MI	NI	VI	MI	NI	VI	MI	NI	VI	MI	NI
Foreign policy	8	54	37	17	54	28	14	51	35	15	53	32	14	55	31	22	57	22	19	54	26	10	52	37	10	52	38
New scientific discoveries	10	52	37	13	49	38	13	53	34	13	59	27	14	55	31	14	55	31	12	54	34	13	58	29	19	58	23
New technologies	10	50	39	11	48	40	14	55	32	12	54	34	12	51	36	11	53	35	10	56	33	12	55	33	16	56	28
Space exploration	–	–	–	14	46	40	13	52	34	16	52	32	13	52	34	11	51	38	9	48	44	9	48	43	16	50	34
Energy/nuclear power[a]	18	58	23	23	56	21	19	56	24	16	55	29	13	47	39	12	50	38	10	43	46	9	40	51	10	41	49
Medical discoveries	–	–	–	–	–	–	–	–	–	24	57	18	22	59	19	24	57	20	22	58	21	23	57	20	28	56	16
Environmental issues	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	32	55	13	29	56	15	24	56	20	23	55	21
Economic policy	14	55	31	29	51	20	28	52	20	22	51	26	22	55	22	25	55	20	29	54	17	25	53	22	25	51	24
Sample size		1,635			3,195			1,631			2,005			2,041			2,033			2,001			2,006			2,000	

VI = very well-informed; MI = moderately well-informed; NI = poorly informed; – = not asked

NOTES: Responses are to the statement: "Now I'd like to go through this list with you again, and for each issue I'd like you to tell me if you are very well-informed, moderately well-informed, or poorly informed." "Don't know" responses are not included. Percentages may not total 100 because of rounding.

[a] In 1990, 1992, 1995, and 1997 the question was worded "…issues about the use of nuclear energy to generate electricity." From 1979 to 1985, the question was worded "…issues about energy policy." In 1988, the question was worded "…issues about the use of nuclear power to generate electricity."

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

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Appendix table 7-6.
Mean score on indices of informedness on scientific and technological issues, by sex and level of education: 1997
(Mean index scores)

Sex and level of education	New scientific discoveries	New technologies	Medical discoveries	Space exploration	Nuclear energy	Environmental issues	Sample size
All adults	49	44	56	41	31	51	2,000
Sex							
Male	51	47	52	49	33	52	930
Female	47	41	60	34	28	50	1,070
Formal education							
Less than high school	45	42	58	36	38	54	420
High school graduate	47	43	55	41	28	49	1,188
Baccalaureate degree	55	49	57	46	29	52	257
Graduate/professional degree	60	54	61	50	34	58	135
Science/mathematics education[a]							
Low	44	41	56	37	30	50	1,112
Middle	48	45	54	43	30	53	509
High	63	54	61	53	32	53	379

NOTES: Each index is a summary measure of respondent reports that they are "very well-informed," "moderately well-informed," or "poorly informed" about each specific issue. A value of 100 was assigned to a "very well-informed" response, and a value of 50 was assigned to a "moderately well-informed" response.

[a] Respondents were classified as having a "high" level of science/mathematics education if they took nine or more high school and college science/math courses. They were classified as "middle" if they took six to eight such courses, and as "low" if they took five or fewer.

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

See figure 7-2.

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Appendix table 7-7.
Public attentiveness to selected issues: 1979-97
(Percentages)

Issue	1979	1981	1983	1985	1988	1990	1992	1995	1997
Foreign policy									
Attentive public	6	6	8	8	8	14	11	5	5
Interested public	16	29	23	25	25	34	27	16	18
Residual public	78	65	70	67	67	52	62	79	77
New scientific discoveries									
Attentive public	7	9	9	8	8	8	7	7	11
Interested public	29	28	40	36	34	31	29	37	38
Residual public	64	63	52	56	57	61	64	56	51
New inventions & technologies									
Attentive public	6	8	8	8	7	7	6	6	9
Interested public	27	26	34	31	33	32	30	37	38
Residual public	67	67	58	61	60	61	63	57	53
Science and technology policy[a]									
Attentive public	9	12	13	12	11	11	10	10	14
Interested public	37	35	48	44	42	40	40	47	46
Residual public	54	54	39	45	46	49	50	43	40
Space exploration									
Attentive public	–	7	7	9	8	6	5	5	8
Interested public	–	18	20	20	26	20	17	20	24
Residual public	–	75	73	71	66	74	78	75	68
Energy/nuclear power[b]									
Attentive public	–	–	15	9	8	8	6	4	4
Interested public	–	–	25	28	30	34	26	25	25
Residual public	–	–	61	63	62	58	68	71	71
Medical discoveries									
Attentive public	–	–	–	17	16	16	17	15	19
Interested public	–	–	–	51	56	52	49	53	52
Residual public	–	–	–	32	28	32	34	31	29
Environmental issues									
Attentive public	–	–	–	–	–	20	18	13	12
Interested public	–	–	–	–	–	43	41	40	40
Residual public	–	–	–	–	–	36	41	48	48
Economic policy									
Attentive public	9	12	19	16	15	17	19	15	14
Interested public	26	40	38	32	33	34	38	32	32
Residual public	65	48	43	52	52	50	44	53	54
Sample size	1,635	3,195	1,631	2,005	2,041	2,033	2,001	2,006	2,000

– = not asked

NOTES: Responses are to the statements: "There are a lot of issues in the news, and it is hard to keep up with every area. I'm going to read to you a short list of issues, and for each one—as I read it—I would like you to tell me if you are very interested, moderately interested, or not at all interested"; "Now I'd like to go through this list with you again, and for each issue I'd like you to tell me if you are very well-informed, moderately well-informed, or poorly informed"; and "Now let me change the topic slightly and ask you how you get information. First, how often do you read a newspaper: every day, a few times a week, once a week, or less than once a week? Are there any magazines that you read regularly, that is, most of the time? What magazine would that be? Is there another magazine that you read regularly? What magazine would that be?" Percentages may not total 100 because of rounding.

To be classified as attentive to a given issue area, respondents must indicate that they are "very interested" in that area, that they are "very well-informed" about it, and that they regularly read a daily newspaper or relevant national magazine. Citizens who report that they are "very interested" in an issue area, but who do not think that they are "very well-informed" about it, are classified as the "interested public." All other individuals are classified as members of the "residual public" for that issue area.

[a] The attentive public for science and technology combines the attentive public for new scientific discoveries and the attentive public for new inventions and technologies. Any individual who is not attentive to either of those issues but who is a member of the interested public for at least one of those issues is classified as a member of the interested public for science and technology. All other individuals are classified as members of the residual public for science and technology.

[b] In 1990, 1992, 1995, and 1997 the question was worded "...issues about the use of nuclear energy to generate electricity." From 1979 to 1985, the question was worded "...issues about energy policy." In 1988, the question was worded "...issues about the use of nuclear power to generate electricity."

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

See figure 7-4.

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Appendix table 7-8.
Public attentiveness to scientific and technological issues, by sex and level of education: 1997
(Percentages)

Sex and level of education	New scientific discoveries AP	New scientific discoveries IP	New technologies AP	New technologies IP	Science and technology policy[a] AP	Science and technology policy[a] IP	Medical discoveries AP	Medical discoveries IP	Space exploration AP	Space exploration IP	Nuclear energy AP	Nuclear energy IP	Environmental issues AP	Environmental issues IP	Sample size
All adults	11	38	9	38	14	46	19	52	8	24	4	25	12	40	2,000
Sex															
Male	12	39	11	43	16	49	15	51	14	28	5	24	14	35	930
Female	9	38	7	34	13	43	23	53	4	20	3	26	11	45	1,070
Formal education															
Less than high school	9	32	9	25	15	34	21	43	6	18	6	27	10	41	420
High school graduate	9	39	8	40	12	49	16	56	8	24	3	24	11	41	1,188
Baccalaureate degree	15	43	10	46	18	51	24	48	13	30	5	26	16	37	257
Graduate/professional degree	23	47	22	41	30	49	24	51	16	25	8	29	22	40	135
Science/mathematics education[b]															
Low	7	34	6	33	10	42	18	51	6	19	3	24	11	41	1,112
Middle	9	43	9	41	14	50	16	57	7	27	6	25	12	41	509
High	22	47	17	47	28	50	25	48	17	34	6	27	17	37	379

AP = attentive public; IP = interested public

NOTES: **Responses are to the statements: "There are a lot of issues in the news, and it is hard to keep up with every area.** I'm going to read to you a short list of issues, and for each one—as I read it—I would like you to **tell me if you are very interested, moderately interested, or not at all interested"**; "Now I'd like to go through this list with you again, and for each issue I'd like you to **tell me if you are very well-informed,** moderately well-informed, or poorly informed"; and "Now let me change the topic slightly and ask you how you get information. First, how often do you read a newspaper: **every day, a few times a week,** once a week, or less than once a week? Are there any magazines that you read regularly, that is, most of the time? What magazine would that be? Is there another magazine that you read regularly? What magazine would that be?"

To be classified as attentive to a given issue area, respondents must indicate that they are "very interested" in that area, that they are "very well-informed" about it, and that they regularly read a daily newspaper or relevant national magazine. Citizens who report that they are "very interested" in an issue area, but who do not think that they are "very well-informed" about it, are classified as the "interested public." All other individuals are classified as members of the "residual public" for that issue area.

[a] The attentive public for science and technology combines the attentive public for new scientific discoveries and the attentive public for new inventions and technologies. Any individual who is not attentive to either of those issues but who is a member of the interested public for at least one of those issues is classified as a member of the interested public for science and technology. All other individuals are classified as members of the residual public for science and technology.

[b] Respondents were classified as having a "high" level of science/mathematics education if they took nine or more high school and college science/math courses. They were classified as "middle" if they took six to eight such courses, and as "low" if they took five or fewer.

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

See figure 7-5.

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Appendix table 7-9.

U.S. public understanding of scientific vocabulary and concepts, by selected characteristics: 1997

(Percentages)

Characteristic	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	Sample size
All adults	82	71	84	62	39	44	43	32	78	44	93	51	59	75	73	48	22	11	13	11	2,000
Sex																					
Male	89	80	88	54	56	53	36	39	86	50	94	53	67	88	82	58	26	17	16	16	930
Female	76	64	81	69	24	36	49	26	71	38	92	49	53	64	64	40	18	7	11	6	1,070
Formal education																					
Less than high school	75	55	77	41	25	25	20	25	67	38	91	37	44	61	51	29	8	1	5	1	420
High school graduate	82	71	86	66	35	42	43	30	78	40	93	52	61	76	75	49	18	9	12	9	1,188
Baccalaureate degree	88	88	89	72	62	66	64	43	86	55	93	60	69	84	86	62	48	28	25	21	257
Graduate/ professional degree	90	92	85	75	68	70	71	49	96	68	96	69	78	90	91	72	49	30	23	33	135
Science/mathematics education[a]																					
Low	76	60	80	57	28	29	33	28	72	38	92	42	54	67	62	35	9	3	9	4	1,112
Middle	86	78	91	64	40	49	47	30	80	41	92	58	61	81	81	56	25	12	12	11	509
High	93	94	87	77	70	79	67	45	92	64	96	68	73	89	93	77	56	36	27	31	,379
Attentiveness to science and technology[b]																					
Attentive public	89	86	89	61	56	56	49	45	87	63	94	59	66	78	85	66	36	21	23	23	288
Interested public	85	75	84	66	43	49	47	34	81	46	93	54	64	78	76	51	25	14	14	11	918
Residual public	75	61	82	58	27	33	36	25	71	35	92	45	52	70	64	39	13	5	8	6	794

NOTE: Understanding is determined by correct responses to the following statements:

A = "The center of the earth is very hot." (True); B = "All radioactivity is man-made." (False); C = "The oxygen we breathe comes from plants." (True); D = "It is the father's gene which decides whether the baby is a boy or a girl." (True); E = "Lasers work by focusing soundwaves." (False); F = "Electrons are smaller than atoms." (True); G = "Antibiotics kill viruses as well as bacteria." (False); H = "The universe began with a huge explosion." (True); I = "The continents on which we live have been moving their location for millions of years and will continue to move in the future." (True); J = "Human beings, as we know them today, developed from earlier species of animals." (True); K = "Cigarette smoking causes lung cancer." (True); L = "The earliest humans lived at the same time as the dinosaurs." (False); M = "Radioactive milk can be made safe by boiling it." (False); N = "Which travels faster: light or sound?" (Light); O = "Does the earth go around the sun, or does the sun go around the earth?" (earth around the sun); P = "How long does it take for the earth to go around the sun: one day, one month, or one year?" (One year); Q = "Please tell me, in your own words, what is DNA?"; R = "Please tell me, in your own words, what is a molecule?"; S = "Please tell me, in your own words, what is the Internet?"; T = "Please tell me, in your own words, what is radiation?"

[a] Respondents were classified as having a "high" level of science/mathematics education if they took nine or more high school and college science/math courses. They were classified as "middle" if they took six to eight such courses, and as "low" if they took five or fewer.

[b] The attentive public for science and technology combines the attentive public for new scientific discoveries and the attentive public for new inventions and technologies. Any individual who is not attentive to either of those issues but who is a member of the interested public for at least one of those issues is classified as a member of the interested public for science and technology. All other individuals are classified as members of the residual public for science and technology.

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

See figure 7-6.

Appendix table 7-10.
Mean score on Index of Scientific Construct Understanding, by selected characteristics: 1997
(Mean index scores)

Characteristic	Mean score
All adults	55
Sex	
Male	62
Female	49
Formal education	
Less than high school	44
High school graduate	54
Baccalaureate degree	68
Graduate/professional degree	72
Science/mathematics education[a]	
Low	47
Middle	58
High	74
Attentiveness to science and technology[b]	
Attentive public	65
Interested public	58
Residual public	48

NOTE: The Index of Scientific Construct Understanding is a composite measure of the public understanding of scientific terms and concepts. In 1997, this measure included responses to the following true/false questions: "All radioactivity is man-made"; "Electrons are smaller than atoms"; "The earliest humans lived at the same time as the dinosaurs"; and "The continents on which we live have been moving their location for millions of years and will continue to move in the future." The following short-answer items were also included: "Which travels faster: light or sound?"; "Does the earth go around the sun, or does the sun go around the earth?"; and "How long does it take for the earth to go around the sun: one day, one month, or one year?" Coded verbatim responses to the following open-ended questions were also included: "Please tell me, in your own words, what is DNA?"; "Please tell me, in your own words, what is a molecule?"; and "Please tell me, in your own words, what is radiation?"

[a] Respondents were classified as having a "high" level of science/mathematics education if they took nine or more high school and college science/math courses. They were classified as "middle" if they took six to eight such courses, and as "low" if they took five or fewer.

[b] The attentive public for science and technology combines the attentive public for new scientific discoveries and the attentive public for new inventions and technologies. Any individual who is not attentive to either of those issues but who is a member of the interested public for at least one of those issues is classified as a member of the interested public for science and technology. All other individuals are classified as members of the residual public for science and technology.

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

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Appendix table 7-11.
Public understanding of the nature of scientific inquiry, by selected characteristics: 1997
(Percentages)

Characteristic	Percentage
All adults	27
Sex	
Male	29
Female	25
Formal education	
Less than high school	8
High school graduate	27
Baccalaureate degree	46
Graduate/professional degree	54
Science/mathematics education[a]	
Low	16
Middle	30
High	55
Attentiveness to science and technology[b]	
Attentive public	35
Interested public	31
Residual public	20

NOTE: Responses are to the following questions: "Now, think about this situation. A doctor tells a couple that their *genetic makeup* means that they've got *one in four chances* of having a child with an inherited illness. Does this mean that if their first three children are healthy, the fourth will have the illness? Does this mean that if their first child has the illness, the next three will not? Does this mean that each of the couple's children will have the same risk of suffering from the illness? Does this mean that if they have only three children, none will have the illness?" "Now, let me turn to a slightly different type of question. When you read news stories, you see certain sets of words and terms. We are interested in how many people recognize certain kinds of terms, and I would like to ask you a few brief questions in that regard. First, some articles refer to the results of a scientific study. When you read or hear the term 'scientific study,' do you have a clear understanding of what it means, a general sense of what it means, or little understanding of what it means? *(if clear understanding or general sense):* In your own words, could you tell me what it means to study something scientifically?" "Now, please think about this situation. Two scientists want to know if a certain drug is effective against high blood pressure. The first scientist wants to give the drug to 1,000 people with high blood pressure and see how many of them experience lower blood pressure. The second scientist wants to give the drug to 500 people with high blood pressure, and not give the drug to another 500 people with high blood pressure, and see how many in both groups experience lower blood pressure levels. Which is the better way to test this drug? Why is it better to test the drug this way?"

[a] Respondents were classified as having a "high" level of science/mathematics education if they took nine or more high school and college science/math courses. They were classified as "middle" if they took six to eight such courses, and as "low" if they took five or fewer.

[b] The attentive public for science and technology combines the attentive public for new scientific discoveries and the attentive public for new inventions and technologies. Any individual who is not attentive to either of those issues but who is a member of the interested public for at least one of those issues is classified as a member of the interested public for science and technology. All other individuals are classified as members of the residual public for science and technology.

SOURCES: J.D. Miller and L. Kimmel, Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

See figure 7-9. *Science & Engineering Indicators – 1998*

Appendix table 7-12.

Mean score on Index of Scientific Construct Understanding in 14 industrialized nations: Most recent year

Country (year)	Mean index score	Sample size
United States (1997)	55	2,000
United States (1995)	55	2,000
United States (1990)	54	2,033
Denmark (1992)	55	1,000
The Netherlands (1992)	54	1,000
Great Britain (1992)	53	1,000
France (1992)	52	1,000
Germany (1992)	51	2,000
Belgium (1992)	49	1,000
Italy (1992)	47	1,000
Canada (1989)	46	2,000
Spain (1992)	45	1,000
Ireland (1992)	42	1,000
Greece (1992)	37	1,000
Japan (1991)	36	1,457
Portugal (1992)	33	1,000

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); J.D. Miller, "Public Understanding of Science and Technology in OECD Countries: A Comparative Analysis," paper presented to the 1996 OECD Symposium on Public Understanding of Science and Technology, Tokyo; and J.D. Miller, R. Pardo, and F. Niwa, *Public Attitudes Toward Science and Technology: A Comparative Study of the European Union, the United States, Japan, and Canada* (Madrid: BBV Foundation, 1997).

See figure 7-10.

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Appendix table 7-13.

General attitudes toward science and technology, by selected characteristics: 1992, 1995, and 1997

(Mean index scores)

	1992			1995			1997		
Characteristic	P[a]	R[b]	P/R	P[a]	R[b]	P/R	P[a]	R[b]	P/R
All adults	67	38	1.76	68	39	1.74	70	37	1.89
Sex									
Male	68	39	1.74	69	38	1.82	71	35	2.03
Female	67	38	1.76	67	40	1.68	69	39	1.77
Formal education									
Less than high school	64	49	1.31	63	51	1.24	69	45	1.53
High school graduate	67	39	1.72	68	39	1.74	69	38	1.82
Baccalaureate degree	70	27	2.59	71	29	2.45	74	28	2.64
Graduate/professional degree	71	24	2.96	73	24	3.04	75	24	3.13
Science/mathematics education[c]									
Low	66	43	1.53	67	44	1.52	69	42	1.64
Middle	67	38	1.76	69	35	1.97	71	34	2.09
High	71	24	2.96	71	28	2.54	75	27	2.78
Attentiveness to science and technology[d]									
Attentive public	71	36	1.97	74	30	2.47	75	30	2.50
Interested public	70	36	1.94	69	38	1.82	73	35	2.09
Residual public	65	41	1.59	65	42	1.55	66	43	1.54

P = Index of Scientific Promise; R = Index of Scientific Reservations; P/R = ratio of scores on the two indices

[a] The Index of Scientific Promise includes responses to the following statements: "Now I would like to read you some statements like those you might find in a newspaper or magazine article. For each statement, please tell me if you generally agree or disagree. If you feel especially strongly about a statement, please tell me that you strongly agree or strongly disagree. First, science and technology are making our lives healthier, easier, and more comfortable—do you strongly agree, agree, disagree, or strongly disagree? Most scientists want to work on things that will make life better for the average person—do you strongly agree, agree, disagree, or strongly disagree? With the application of science and new technology, work will become more interesting—do you strongly agree, agree, disagree, or strongly disagree? Because of science and technology, there will be more opportunities for the next generation—do you strongly agree, agree, disagree, or strongly disagree?"

[b] The Index of Scientific Reservations includes responses to the following statements: "Now I would like to read you some statements like those you might find in a newspaper or magazine article. For each statement, please tell me if you generally agree or disagree. If you feel especially strongly about a statement, please tell me that you strongly agree or strongly disagree. We depend too much on science and not enough on faith—do you strongly agree, agree, disagree, or strongly disagree? It is not important for me to know about science in my daily life—do you strongly agree, agree, disagree, or strongly disagree? Science makes our way of life change too fast—do you strongly agree, agree, disagree, or strongly disagree? Now for a different type of question. People have frequently noted that scientific research has produced both beneficial and harmful consequences. Would you say that, on balance, the benefits of scientific research have outweighed the harmful results, or have the harmful results of scientific research been greater than its benefits? *(if benefits greater):* Would you say that the balance has been strongly in favor of beneficial results, or only slightly? *(if harms greater):* Would you say that the balance has been strongly in favor of harmful results, or only slightly?"

[c] Respondents were classified as having a "high" level of science/mathematics education if they took nine or more high school and college science/math courses. They were classified as "middle" if they took six to eight such courses, and as "low" if they took five or fewer.

[d] The attentive public for science and technology combines the attentive public for new scientific discoveries and the attentive public for new inventions and technologies. Any individual who is not attentive to either of those issues but who is a member of the interested public for at least one of those issues is classified as a member of the interested public for science and technology. All other individuals are classified as members of the residual public for science and technology.

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

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Appendix table 7-14.

Responses to items in the Index of Scientific Promise and the Index of Scientific Reservations: 1997

(Percentages)

Item	Strongly agree	Agree	Don't know	Disagree	Strongly disagree
Index of Scientific Promise					
Science and technology are making our lives healthier, easier, and more comfortable	29	60	2	7	2
Most scientists want to work on things that will make life better for the average person	11	68	4	15	2
With the application of science and new technology, work will become more interesting	9	63	6	21	1
Because of science and technology, there will be more opportunities for the next generation	13	68	4	14	1
Index of Scientific Reservations					
We depend too much on science and not enough on faith	12	35	6	39	8
It is not important for me to know about science in my daily life	2	12	1	58	27
Science makes our way of life change too fast	4	32	2	55	6
	B>>H	**B>H**	**B=H**	**H>B**	**H>>B**
Have the benefits of scientific research outweighed the harmful results or have the harmful results outweighed the benefits?	47	28	13	8	4

B>>H = benefits strongly outweigh the harmful results; B>H = benefits outweigh the harmful results; B=H = benefits equal the harmful results; H>B = harmful results outweigh the benefits; H>>B = harmful results strongly outweigh the benefits

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

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Appendix table 7-15.

Responses to and mean scores on the Attitude Toward Organized Science Scale, by selected characteristics: 1983-97

Response and characteristic	1983	1985	1988	1990	1992	1995	1997
Percentage of the public							
Agree that "science and technology are making our lives healthier easier, and more comfortable"	84	86	87	84	85	86	89
Agree that "the benefits of science are greater than any harmful effects"	57	68	76	72	73	72	75
Disagree that "science makes our way of life change too fast"	50	53	59	60	63	60	61
Disagree that "we depend too much on science and not enough on faith"	43	39	43	44	45	44	48
Mean ATOSS score							
All adults	2.3	2.5	2.7	2.6	2.7	2.6	2.7
Sex							
Male	2.2	2.4	2.6	2.5	2.7	2.7	2.9
Female	2.5	2.6	2.8	2.8	2.6	2.5	2.6
Formal education							
Less than high school	1.8	1.8	2.2	1.8	2.0	2.0	2.2
High school graduate	2.4	2.6	2.8	2.7	2.7	2.6	2.7
Baccalaureate degree	2.9	3.1	3.2	3.1	3.3	3.3	3.2
Graduate/professional degree	2.9	3.1	3.1	3.2	3.3	3.4	3.4
Science/mathematics education[a]							
Low	NA	NA	NA	2.4	2.5	2.3	2.5
Middle	NA	NA	NA	2.9	2.7	2.9	2.9
High	NA	NA	NA	3.3	3.3	3.2	3.3
Attentiveness to science and technology[b]							
Attentive public	2.6	2.8	3.0	2.8	2.9	3.1	3.0
Interested public	2.4	2.6	2.8	2.7	2.8	2.7	2.9
Residual public	2.1	2.3	2.5	2.5	2.5	2.4	2.4
Sample size	1,631	2,005	2,041	2,033	997	2,006	2,000

ATOSS = Attitude Toward Organized Science Scale; NA = not available

NOTES: Responses are to the following statement: "Now I would like to read you some statements like those you might find in a newspaper or magazine article. For each statement, please tell me if you generally agree or disagree. If you feel especially strongly about a statement, please tell me that you strongly agree or strongly disagree." The scale is a count of agreement with the first two items and disagreement with the second two items.

[a] Respondents were classified as having a "high" level of science/mathematics education if they took nine or more high school and college science/math courses. They were classified as "middle" if they took six to eight such courses, and as "low" if they took five or fewer.

[b] The attentive public for science and technology combines the attentive public for new scientific discoveries and the attentive public for new inventions and technologies. Any individual who is not attentive to either of those issues but who is a member of the interested public for at least one of those issues is classified as a member of the interested public for science and technology. All other individuals are classified as members of the residual public for science and technology.

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated* Codebook (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

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Appendix table 7-16.

General attitudes toward science and technology in 14 industrialized nations: Most recent year

(Mean index scores)

Country (year)	Index of Scientific Promise	Index of Scientific Reservation	Ratio of indices
United States (1997)	70	37	1.89
United States (1995)	68	39	1.74
United States (1992)	67	38	1.76
Canada (1989)	72	56	1.29
Italy (1992)	69	54	1.28
Ireland (1992)	69	55	1.26
Great Britain (1992)	68	56	1.21
France (1992)	68	56	1.21
Belgium (1992)	64	54	1.19
Denmark (1992)	72	61	1.18
The Netherlands (1992)	69	59	1.17
Germany (1992)	70	60	1.17
Spain (1992)	71	62	1.15
Portugal (1992)	71	67	1.06
Greece (1992)	75	74	1.01
Japan (1991)	55	56	0.98

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); unpublished tabulations; and J. D. Miller, R. Pardo, and F. Niwa, *Public Attitudes Toward Science and Technology: A Comparative Study of the European Union, the United States, Japan, and Canada* (Madrid: BBV Foundation, 1997).

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Appendix table 7-17.

Public assessments of funding of scientific research by the Federal Government, by selected characteristics: 1985-97

(Percentages)

Characteristic	1985	1988	1990	1992	1995	1997
All adults						
Strongly agree	9	16	17	14	19	22
Agree	70	65	62	63	61	57
Don't know	5	4	4	3	3	3
Disagree	16	14	15	18	17	15
Strongly disagree	0	1	2	2	2	3
Male						
Strongly agree	11	20	23	17	19	24
Agree	71	63	60	62	60	54
Don't know	2	2	2	2	2	3
Disagree	15	13	13	17	18	16
Strongly disagree	1	2	2	2	1	3
Female						
Strongly agree	8	11	13	11	15	20
Agree	68	68	65	64	62	59
Don't know	8	6	5	4	5	4
Disagree	16	14	16	19	16	15
Strongly disagree	0	1	1	2	2	2
Less than high school graduate						
Strongly agree	5	6	10	10	8	20
Agree	65	66	59	61	59	50
Don't know	9	7	8	5	7	5
Disagree	21	18	20	21	24	22
Strongly disagree	0	3	3	3	2	3
High school graduate						
Strongly agree	8	17	18	12	16	19
Agree	72	66	65	64	63	60
Don't know	4	3	2	3	3	3
Disagree	15	13	14	19	17	15
Strongly disagree	1	1	1	2	1	3
Baccalaureate degree						
Strongly agree	19	26	27	22	24	31
Agree	68	62	60	64	62	56
Don't know	2	3	2	2	2	2
Disagree	10	8	10	12	11	10
Strongly disagree	1	1	1	0	1	1
Graduate/professional degree						
Strongly agree	20	29	31	26	43	40
Agree	70	61	58	53	46	51
Don't know	2	2	4	5	2	2
Disagree	8	7	6	14	8	5
Strongly disagree	0	1	1	2	1	2
Attentive public for science and technology[a]						
Strongly agree	17	27	35	28	35	46
Agree	76	62	50	61	48	42
Don't know	0	2	4	1	1	1
Disagree	6	8	10	9	14	7
Strongly disagree	1	1	1	1	2	4

NOTE: Responses are to the question: "Even if it brings no immediate benefits, scientific research which advances the frontiers of knowledge is necessary and should be supported by the Federal Government. Do you strongly agree, agree, disagree, or strongly disagree?"

[a] The attentive public for science and technology contains the attentive public for new scientific discoveries and the attentive public for new inventions and technologies.

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

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Appendix table 7-18.

Public attitudes toward federal support of basic scientific research, by general attitudes on science and technology and selected characteristics: 1997

(Percentages)

Characteristic	Disagree	Unsure	Agree	Sample size	Gamma[a]
INDEX OF SCIENTIFIC PROMISE[b]					
All adults	18	3	79	2,000	–
Low score on Index of Scientific Promise	37	9	54	241	
Moderate score on Index of Scientific Promise	25	4	71	626	0.54
High score on Index of Scientific Promise	10	1	89	1,133	
Less than high school graduate	25	5	70	421	–
Low score	35	18	47	57	
Moderate score	39	4	57	147	0.51
High score	14	1	85	217	
High school graduate	18	4	78	1,188	–
Low score	41	7	52	152	
Moderate score	23	5	72	379	0.54
High score	10	2	88	657	
Baccalaureate degree	10	2	88	393	–
Low score	21	6	73	33	
Moderate score	14	2	84	100	0.42
High score	7	1	92	260	
INDEX OF SCIENTIFIC RESERVATIONS[c]					
All adults	18	3	79	2,000	–
Low score on Index of Scientific Reservations	9	1	90	831	
Moderate score on Index of Scientific Reservations	23	4	73	806	-0.43
High score on Index of Scientific Reservations	27	6	67	363	
Less than high school graduate	25	4	71	421	–
Low score	8	0	92	79	
Moderate score	37	5	58	218	-0.07
High score	16	6	78	122	
High school graduate	18	3	79	1,188	–
Low score	9	2	89	493	
Moderate score	20	4	76	478	-0.47
High score	33	7	60	217	
Baccalaureate degree	10	1	89	393	–
Low score	8	1	91	254	
Moderate score	10	3	87	109	-0.27
High score	21	4	75	24	

[a] The ordinal correlation coefficient gamma is a measure of the bivariate relationship between two ordinal variables. It is equivalent to R^2 for two interval variables. See L.A. Goodman and W.H. Kruskal "Measures of Association for Cross-Classifications," *Journal of the American Statistical Association* Vol. 49 (1954): 732-64; and H.L. Costner, "Criteria for Measures of Association," *American Sociological Review* Vol. 30, No. 3 (1965): 341-53.

[b] The Index of Scientific Promise scores are classified as follows: low = 0-49; moderate = 50-74; and high = 75-100.

[c] The Index of Scientific Reservations scores are classified as follows: low = 0-29; moderate = 30-54; and high = 55+.

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

See figure 7-11.

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Appendix table 7-19.

Public confidence in the people running various institutions: 1973-96

(Percentages)

Institution	1973	1974	1975	1976	1977	1978	1980	1982	1983	1984	1986	1987	1988	1989	1990	1991	1993	1994	1996
Average[a]	30	33	26	29	31	24	26	26	24	27	25	28	26	25	25	29	22	22	23
Medicine	54	60	50	54	51	46	52	45	51	50	46	52	51	46	46	48	39	41	45
Scientific community	37	45	39	43	41	36	41	38	41	44	39	45	39	40	37	41	37	38	39
U.S. Supreme Court	31	33	31	35	35	28	25	30	27	33	30	36	35	34	35	37	31	30	28
Military	32	40	35	39	36	29	28	31	29	36	31	34	34	32	33	60	42	37	37
Education	37	49	31	37	41	28	30	33	29	28	28	35	29	30	27	30	22	25	23
Major companies	29	31	19	22	27	22	27	23	24	30	24	30	25	24	25	20	21	25	23
Organized religion	35	44	24	30	40	31	35	32	28	31	25	29	20	22	23	25	23	24	25
Exec. branch of Fed. Govt.	29	14	13	13	28	12	12	19	13	18	21	18	16	20	23	26	12	11	10
Banks & financial institutions	–	–	32	39	42	33	32	27	24	31	21	27	27	19	18	12	15	18	25
Congress	23	17	13	14	19	13	9	13	10	12	16	16	15	17	15	18	7	8	8
Press	23	26	24	28	25	20	22	18	13	17	18	18	18	17	15	16	11	8	11
TV	18	23	18	19	17	14	16	14	12	13	15	12	14	14	14	14	12	9	10
Organized labor	15	18	10	12	15	11	15	12	8	8	8	10	10	9	11	11	8	10	11
Sample size	1,504	1,484	1,490	1,499	1,530	1,532	1,468	1,506	1,599	989	1,470	1,466	997	1,035	899	1,017	1,057	2,011	1,925

– = not asked

NOTES: Percentages represent those respondents expressing a "great deal of confidence" when asked the following: "I am going to name some institutions in this country. As far as the people running these institutions are concerned, would you say that you have a great deal of confidence, only some confidence, or hardly any confidence at all in them?" Survey was not conducted in 1979 and 1981, and the question was not asked in 1985.

[a] Average does not include banks and financial institutions.

SOURCE: J.A. Davis and T.W. Smith, *General Social Surveys, Cumulative Codebook* (Chicago: University of Chicago, National Opinion Research Center, annual series).

See figure 7-12.

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Appendix table 7-20.

Public assessments of scientific research, by selected characteristics: 1979-97

Characteristic	1979	1981	1985	1988	1990	1992	1995	1997
				Percentages				
All adults								
Benefits strongly outweigh harmful results	46	42	44	57	47	42	43	47
Benefits slightly outweigh harmful results	24	28	24	25	25	31	29	28
Benefits equal harmful results	19	13	13	5	15	11	16	13
Harmful results slightly outweigh benefits	7	12	13	9	10	12	10	8
Harmful results strongly outweigh benefits	4	5	6	4	3	4	3	4
Male								
Benefits strongly outweigh harmful results	51	48	48	59	54	45	47	52
Benefits slightly outweigh harmful results	23	27	23	25	24	30	28	27
Benefits equal harmful results	16	11	10	5	9	9	13	10
Harmful results slightly outweigh benefits	7	10	13	7	9	11	9	7
Harmful results strongly outweigh benefits	3	5	6	4	4	5	4	
Female								
Benefits strongly outweigh harmful results	42	37	40	55	40	40	39	42
Benefits slightly outweigh harmful results	25	28	26	25	26	31	30	29
Benefits equal harmful results	23	16	14	6	20	13	19	15
Harmful results slightly outweigh benefits	6	14	14	10	11	12	10	10
Harmful results strongly outweigh benefits	4	5	6	4	3	4	3	4
Less than high school graduate								
Benefits strongly outweigh harmful results	26	26	20	37	24	24	18	30
Benefits slightly outweigh harmful results	25	23	21	30	25	33	30	28
Benefits equal harmful results	32	25	26	9	30	17	34	21
Harmful results slightly outweigh benefits	12	18	20	17	17	20	14	18
Harmful results strongly outweigh benefits	5	9	13	7	4	7	3	3
High school graduate								
Benefits strongly outweigh harmful results	50	43	47	59	49	41	44	46
Benefits slightly outweigh harmful results	26	31	26	25	27	32	30	30
Benefits equal harmful results	16	10	10	5	11	10	13	13
Harmful results slightly outweigh benefits	5	12	13	7	10	12	10	6
Harmful results strongly outweigh benefits	3	4	4	4	3	5	3	5
Baccalaureate or higher degree								
Benefits strongly outweigh harmful results	69	64	67	80	72	66	67	67
Benefits slightly outweigh harmful results	18	22	23	16	18	22	23	23
Benefits equal harmful results	8	7	2	1	6	8	6	6
Harmful results slightly outweigh benefits	2	4	6	2	2	3	3	3
Harmful results strongly outweigh benefits	3	2	2	1	2	2	1	1
Attentive public for science and technology								
Benefits strongly outweigh harmful results	67	63	59	62	61	48	64	64
Benefits slightly outweigh harmful results	16	20	17	23	19	27	21	19
Benefits equal harmful results	8	5	7	6	10	12	8	6
Harmful results slightly outweigh benefits	4	8	13	6	6	9	3	8
Harmful results strongly outweigh benefits	5	4	4	3	4	4	4	3
				Sample size				
All adults	1,635	1,536	2,005	975	2,033	997	2,006	2,000
Male	773	724	950	475	964	464	953	930
Female	862	812	1,054	500	1,070	533	1,053	1,070
Less than high school graduate	465	385	507	259	495	215	418	420
High school graduate	932	886	1,147	546	1,202	579	1,196	1,188
Baccalaureate or higher degree	238	264	349	170	336	203	392	392
Attentive public for science and technology[a]	154	381	235	116	229	94	195	288

NOTES: Responses are for the following statements: "People have frequently noted that scientific research has produced both beneficial and harmful consequences. Would you say that, on balance, the benefits of scientific research have outweighed the harmful results, or have the harmful results of scientific research been greater than its benefits? Would you say that the balance has been strongly in favor of beneficial results or only slightly? Would you say that the balance has been strongly in favor of harmful results or only slightly?" Percentages may not total 100 because of rounding.

[a] The attentive public for science and technology contains the attentive public for new scientific discoveries and the attentive public for new inventions and technologies.

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

See figure 7-13.

Appendix table 7-21.

Public assessments of nuclear power, by selected characteristics: 1985-97

Characteristic	1985	1988	1990	1992	1995	1997
	Percentages					
All adults						
Benefits strongly outweigh harmful results	28	18	24	17	21	22
Benefits slightly outweigh harmful results	22	24	23	30	22	23
Benefits equal harmful results	6	11	12	11	14	18
Harmful results slightly outweigh benefits	13	17	13	15	21	17
Harmful results strongly outweigh benefits	31	30	28	27	21	20
Male						
Benefits strongly outweigh harmful results	38	23	31	21	29	28
Benefits slightly outweigh harmful results	22	27	24	34	23	26
Benefits equal harmful results	4	7	8	7	8	13
Harmful results slightly outweigh benefits	9	15	11	10	21	13
Harmful results strongly outweigh benefits	27	28	26	28	19	20
Female						
Benefits strongly outweigh harmful results	19	14	17	14	14	17
Benefits slightly outweigh harmful results	22	21	21	27	21	20
Benefits equal harmful results	8	14	16	14	20	22
Harmful results slightly outweigh benefits	16	19	16	18	23	20
Harmful results strongly outweigh benefits	35	32	30	27	22	21
Less than high school graduate						
Benefits strongly outweigh harmful results	28	15	21	10	15	20
Benefits slightly outweigh harmful results	24	25	21	37	16	17
Benefits equal harmful results	8	17	23	11	25	25
Harmful results slightly outweigh benefits	14	19	13	13	28	21
Harmful results strongly outweigh benefits	26	24	22	29	16	17
High school graduate						
Benefits strongly outweigh harmful results	27	18	23	19	21	22
Benefits slightly outweigh harmful results	21	23	23	26	23	23
Benefits equal harmful results	6	9	9	11	13	16
Harmful results slightly outweigh benefits	13	17	14	16	21	16
Harmful results strongly outweigh benefits	33	33	31	28	23	23
Baccalaureate or higher degree						
Benefits strongly outweigh harmful results	29	22	32	19	28	25
Benefits slightly outweigh harmful results	21	25	23	34	26	26
Benefits equal harmful results	3	7	7	10	8	14
Harmful results slightly outweigh benefits	13	14	13	14	18	17
Harmful results strongly outweigh benefits	3	32	25	23	19	18
Attentive public for science and technology[a]						
Benefits strongly outweigh harmful results	35	26	30	24	28	25
Benefits slightly outweigh harmful results	20	24	27	30	24	25
Benefits equal harmful results	1	9	6	10	10	11
Harmful results slightly outweigh benefits	12	16	9	9	22	17
Harmful results strongly outweigh benefits	32	25	28	27	18	22

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Appendix table 7-21.
Public assessments of nuclear power, by selected characteristics: 1985-97

Characteristic	1985	1988	1990	1992	1995	1997
			Sample size			
All adults	2,005	2,041	2,033	997	2,006	2,000
Male	950	958	964	464	953	930
Female	1,054	1,084	1,070	533	1,053	1,070
Less than high school graduate	507	530	495	215	418	420
High school graduate	1,143	1,158	1,202	579	1,196	1,188
Baccalaureate or higher degree	349	353	336	203	392	392
Attentive public for science and technology	235	233	229	94	195	288

NOTES: In 1985, 1988, 1990, 1995 and 1997, the question was worded, "In the current debate over the use of nuclear reactors to generate electricity, there is a broad agreement that there are some risks and some benefits associated with nuclear power. In your opinion, have the benefits associated with nuclear power outweighed the harmful results, or have the harmful results associated with nuclear power been greater than its benefits? Would you say that the balance has been strongly in favor of beneficial results or only slightly? Would you say that the balance has been strongly in favor of beneficial results or only slightly? Would you say that the balance has been strongly in favor of harmful results or only slightly?" In 1992, the question was worded, "In the current debate over the use of nuclear reactors to generate electricity, there is broad agreement that there are some costs and some benefits associated with nuclear power. In your opinion, are the costs associated with nuclear power greater than the benefits, or are the benefits associated with nuclear power greater than the costs? Would you say that the benefits have substantially exceeded the costs or only slightly exceeded the costs? Would you say that the costs substantially exceeded the benefits or only slightly exceed the benefits?" Percentages may not total 100 because of rounding.

[a]The attentive public for science and technology contains the attentive public for new scientific discoveries and the attentive public for new inventions and technologies.

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

See figure 7-14.

Appendix table 7-22.
Public assessments of genetic engineering, by selected characteristics: 1985-97

Characteristic	1985	1990	1995	1997
	Percentages			
All adults				
Benefits strongly outweigh harmful results	23	20	21	19
Benefits slightly outweigh harmful results	26	27	22	23
Benefits equal harmful results	12	16	22	22
Harmful results slightly outweigh benefits	14	19	23	20
Harmful results strongly outweigh benefits	25	18	12	16
Male				
Benefits strongly outweigh harmful results	26	21	24	23
Benefits slightly outweigh harmful results	28	31	22	26
Benefits equal harmful results	11	14	21	20
Harmful results slightly outweigh benefits	13	18	22	17
Harmful results strongly outweigh benefits	22	16	10	14
Female				
Benefits strongly outweigh harmful results	19	19	18	16
Benefits slightly outweigh harmful results	25	23	22	21
Benefits equal harmful results	14	17	22	23
Harmful results slightly outweigh benefits	15	21	23	22
Harmful results strongly outweigh benefits	27	20	15	18
Less than high school graduate				
Benefits strongly outweigh harmful results	19	16	10	15
Benefits slightly outweigh harmful results	29	27	19	18
Benefits equal harmful results	16	25	30	23
Harmful results slightly outweigh benefits	12	17	29	30
Harmful results strongly outweigh benefits	24	15	13	14
High school graduate				
Benefits strongly outweigh harmful results	21	19	20	18
Benefits slightly outweigh harmful results	24	27	21	24
Benefits equal harmful results	13	12	21	21
Harmful results slightly outweigh benefits	15	21	23	18
Harmful results strongly outweigh benefits	27	21	14	19
Baccalaureate or higher degree				
Benefits strongly outweigh harmful results	33	29	35	27
Benefits slightly outweigh harmful results	29	28	30	28
Benefits equal harmful results	7	15	16	21
Harmful results slightly outweigh benefits	13	15	14	14
Harmful results strongly outweigh benefits	18	13	6	10
Attentive public for science and technology[a]				
Benefits strongly outweigh harmful results	37	32	42	36
Benefits slightly outweigh harmful results	28	30	22	24
Benefits equal harmful results	9	9	16	13
Harmful results slightly outweigh benefits	12	12	13	16
Harmful results strongly outweigh benefits	14	17	7	11
Attentive public for medical research				
Benefits strongly outweigh harmful results	29	31	34	27
Benefits slightly outweigh harmful results	24	27	21	25
Benefits equal harmful results	12	12	17	18
Harmful results slightly outweigh benefits	11	17	18	18
Harmful results strongly outweigh benefits	24	13	9	12

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Appendix table 7-22.

Public assessments of genetic engineering, by selected characteristics: 1985-97

Characteristic	1985	1990	1995	1997
	Sample size			
All adults	2,005	2,033	2,006	2,000
Male	950	964	953	930
Female	1,054	1,070	1,053	1,070
Less than high school graduate	507	495	418	420
High school graduate	1,143	1,179	1,196	1,188
Baccalaureate or higher degree	349	359	392	392
Attentive public for science and technology	235	229	195	288
Attentive public for medical research	349	337	310	377

NOTES: In 1985, the question was worded, "Some persons have argued that the creation of new life forms through genetic engineering constitutes a serious risk, while other persons have argued that this research may yield major benefits for society. In your opinion, are the risks of genetic engineering greater than the benefits, or are the benefits of genetic engineering research greater than the risks? Would you say that the benefits are substantially greater than the risks, or only slightly greater than the risks? Would you say that the risks are substantially greater than the benefits or only slightly greater than the benefits?" In 1990, the question was worded, "Some persons have argued that the creation of new life forms through genetic engineering research constitutes a serious risk, while other persons have argued that this research may yield major benefits for society. In your opinion, are the risks of genetic engineering research greater than its benefits, or are the benefits of genetic engineering research greater than its risks? Would you say that the benefits have substantially exceeded the risks or only slightly exceeded the risks? Would you say that the risks have substantially exceeded the benefits or only slightly exceeded the benefits?" In 1995, the question was worded, "Some persons have argued that the creation of new life forms through genetic engineering research constitutes a serious risk, while other persons have argued that this research may yield major benefits for society. In your opinion, have the benefits of genetic engineering research outweighed the harmful results, or have the harmful results of genetic engineering research been greater than its benefits? Would you say that balance has been strongly in favor of beneficial results or only slightly? Would you say that the balance has been strongly in favor of harmful results or only slightly?" In 1997, half of the respondents were asked the question used in 1995. The other half were asked: "Some persons have argued that the modification of existing life forms through genetic engineering research constitutes a serious risk, while other persons have argued that this research may yield major benefits for society. In your opinion, have the benefits of engineering research outweighed the harmful results, or have the harmful results of genetic engineering research been greater than its benefits? Would you say that the balance has been strongly in favor of beneficial results or only slightly? Would you say that the balance has been strongly in favor of harmful results or only slightly?" Percentages may not total 100 because of rounding.

[a] The attentive public for science and technology contains the attentive public for new scientific discoveries and the attentive public for new inventions and technologies.

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

See figure 7-15.

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Appendix table 7-23.
Public assessments of space exploration, by selected characteristics: 1985-97

Characteristic	1985	1988	1990	1992	1995	1997
			Percentages			
All adults						
Benefits strongly outweigh costs	27	22	18	17	22	24
Benefits slightly outweigh costs	27	25	25	26	24	24
Benefits equal costs	7	9	9	9	8	10
Costs slightly outweigh benefits	15	18	17	22	17	17
Costs strongly outweigh benefits	24	26	31	26	28	25
Male						
Benefits strongly outweigh costs	33	28	23	33	28	31
Benefits slightly outweigh costs	31	27	26	26	25	25
Benefits equal costs	6	10	8	8	6	8
Costs slightly outweigh benefits	12	13	16	16	16	15
Costs strongly outweigh benefits	18	22	27	27	24	21
Female						
Benefits strongly outweigh costs	21	16	14	11	17	18
Benefits slightly outweigh costs	24	23	24	25	23	23
Benefits equal costs	8	9	10	11	10	12
Costs slightly outweigh benefits	17	23	17	27	18	18
Costs strongly outweigh benefits	30	29	35	26	32	29
Less than high school graduate						
Benefits strongly outweigh costs	22	16	15	14	14	18
Benefits slightly outweigh costs	25	26	20	29	20	21
Benefits equal costs	10	9	17	12	13	16
Costs slightly outweigh benefits	17	21	16	24	21	24
Costs strongly outweigh benefits	26	29	32	21	31	21
High school graduate						
Benefits strongly outweigh costs	26	21	17	15	23	23
Benefits slightly outweigh costs	28	25	25	25	24	23
Benefits equal costs	6	9	7	9	6	9
Costs slightly outweigh benefits	14	18	17	23	17	16
Costs strongly outweigh benefits	26	27	34	28	30	29
Baccalaureate or higher degree						
Benefits strongly outweigh costs	36	33	27	22	32	31
Benefits slightly outweigh costs	28	26	28	26	27	29
Benefits equal costs	6	10	7	6	8	8
Costs slightly outweigh benefits	13	15	16	18	14	12
Costs strongly outweigh benefits	17	16	22	28	20	20
Attentive public for science and technology[a]						
Benefits strongly outweigh costs	39	38	26	28	32	44
Benefits slightly outweigh costs	27	28	33	26	25	22
Benefits equal costs	7	6	4	11	7	6
Costs slightly outweigh benefits	13	10	14	20	16	11
Costs strongly outweigh benefits	14	21	23	15	20	17
Attentive public for space exploration						
Benefits strongly outweigh costs	49	46	36	38	52	57
Benefits slightly outweigh costs	25	30	36	44	23	19
Benefits equal costs	8	4	3	3	4	6
Costs slightly outweigh benefits	11	7	11	6	12	10
Costs strongly outweigh benefits	7	13	14	9	9	8

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Appendix table 7-23.

Public assessments of space exploration, by selected characteristics: 1985-97

Characteristic	1985	1988	1990	1992	1995	1997
			Sample size			
All adults	2,005	2,041	2,033	1,004	2,006	2000
Male	950	958	964	486	953	930
Female	1,054	1,084	1,070	533	1,053	1070
Less than high school graduate	507	530	495	215	418	420
High school graduate	1,147	1,158	1,202	623	1,196	1188
Baccalaureate or higher degree	349	353	336	203	392	392
Attentive public for science and technology	235	233	229	105	195	288
Attentive public for space exploration	184	163	123	51	99	168

NOTES: Responses are to the following questions: "Many current issues in science and technology may be viewed as a judgment of relative benefits. Thinking first about the space program, some persons have argued that the costs of the space program may have exceeded its benefits, while other people have argued that the benefits of space exploration have exceeded its costs. In your opinion, have the costs of space exploration exceeded its benefits, or have the benefits of space exploration exceeded its costs? Would you say that the benefits have substantially exceeded the costs, or only slightly exceeded the costs? Would you say that the costs have substantially exceeded the benefits or only slightly exceeded the benefits?" Percentages may not total 100 because of rounding.

[a] The attentive public for science and technology contains the attentive public for new scientific discoveries and the attentive public for new inventions and technologies.

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

See figure 7-16.

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Appendix table 7-24.

Public use of various sources of information, by selected characteristics: 1997

(Percentages)

Characteristic	Read newspaper every day	Read at least 1 news magazine regularly	Watch TV news 1+hr/day	Listen to radio news 1+hr/day	Public library		Read at least 1 science magazine/ month	Watch 1+ science TV programs/ month	Visit science museums 1+/year	Purchase 1+ books/yr		World Wide Web 1+ hrs/wk	Sample size
					1 visit/yr	5 visits/yr				Any	Science		
All adults	46	14	68	28	70	45	15	53	60	61	31	15	2,000
Sex													
Male	49	15	63	29	68	41	20	56	63	55	32	20	930
Female	43	14	72	27	72	48	11	50	59	66	29	10	1,070
Formal education													
Less than high school	41	6	80	31	52	31	9	45	34	33	9	4	420
High school graduate	44	14	67	27	71	43	14	55	64	62	31	11	1,188
Baccalaureate degree	53	22	59	27	87	68	25	57	78	85	51	35	257
Grad./professional degree	59	27	54	27	84	63	29	52	75	87	56	37	135
Science/mathematics education[a]													
Low	43	10	74	26	59	33	9	48	48	48	18	4	1,112
Middle	47	18	65	34	82	57	14	56	75	70	38	19	509
High	53	22	54	27	85	63	33	62	78	86	58	38	379
Attentiveness to science & tech.[b]													
Attentive public	79	25	70	27	78	60	41	64	68	75	44	30	288
Interested public	38	14	68	28	74	48	13	56	66	65	35	15	918
Residual public	42	11	68	32	62	35	7	44	51	51	20	9	794
Access to cable/satellite TV													
Have cable TV	49	15	68	27	72	45	15	57	62	62	31	17	1,331
Have satellite dish	52	10	64	20	50	29	21	56	55	60	32	17	97
Have neither[c]	35	13	69	33	69	47	14	42	57	58	29	10	572

NOTE: Responses are to the statements: "How often do you read a newspaper: every day, a few times a week, once a week, or less than once a week?"; "Are there any magazines that you read regularly, that is, most of the time? What magazine would that be?"; "Altogether, on an average day, about how many hours would you say that you watch television? About how many of those hours are news reports or news shows?"; "Now, let me ask you about your use of museums, zoos, and similar institutions. I am going to read you a short list of places and ask you to tell me how many times you visited each type of place during the last year, that is, the last 12 months. If you did not visit any given place, just say none. A natural history museum—how many times did you visit it during the last year? A zoo or an aquarium—how many times did you visit it during the last year? A science or technology museum—how many times did you visit it during the last year? A public library—how many times did you visit it during the last year?"; "Do you watch any television shows that focus primarily on science or nature? Which science or nature show do you watch most often? About how many times a month do you watch this show?"; and "On an average day, about how many hours would you say that you listen to a radio? About how many of those hours are news reports or news shows?"

[a] Respondents were classified as having a "high" level of science/mathematics education if they took nine or more high school and college science/math courses. They were classified as "middle" if they took six to eight such courses, and as "low" if they took five or fewer.

[b] The attentive public for science and technology combines the attentive public for new scientific discoveries and the attentive public for new inventions and technologies. Any individual who is not attentive to either of those issues but who is a member of the interested public for at least one of those issues is classified as a member of the interested public for science and technology. All other individuals are classified as members of the residual public for science and technology.

[c] This category includes 79 respondents who reported that they did not watch any television.

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

See figure 7-17.

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Appendix table 7-25.

Public use of information on an annual basis, by selected characteristics: 1997

	Hours/year watching/listening to					Copies read/year			Visits/year		Number borrowed/year		
Characteristic	Total TV	TV news	Science TV	Total radio	Radio news	News-papers	News maga-zines	Science maga-zines	Science museum	Public library	Books	Video-tapes	Sample size
All adults	1,075	432	72	944	228	196	3.0	1.7	2.2	11.0	12.1	2.0	2,000
Sex													
Male	992	387	82	986	262	206	2.8	2.5	2.0	9.2	7.7	1.3	930
Female	1,147	471	62	906	198	186	2.8	1.1	2.1	11.8	15.9	2.0	1,070
Formal education													
Less than high school	1,495	553	48	904	207	178	1.7	1.0	1.0	7.6	5.5	0.5	420
High school graduate	1,040	426	81	1,030	233	192	2.5	1.5	2.0	10.0	11.6	1.4	1,188
Baccalaureate degree	743	314	72	798	234	219	4.0	3.0	3.4	16.8	20.0	3.0	257
Grad./professional degree	718	335	59	584	232	238	6.2	4.0	3.3	15.9	21.1	2.2	135
Science/math education[a]													
Low	1,235	489	63	887	208	185	2.0	1.0	2.0	7.7	8.8	1.1	1,112
Middle	973	394	86	1,138	259	200	3.3	1.5	2.9	13.2	13.3	1.6	509
High	744	317	79	850	243	220	4.6	4.1	3.3	15.3	19.9	3.0	379
Attentiveness to science and technology[b]													
Attentive public	1,093	500	102	957	254	298	6.5	5.2	3.1	16.7	18.0	2.3	288
Interested public	1,044	443	84	931	238	171	2.5	1.4	2.5	11.1	13.0	1.5	918
Residual public	1,105	395	46	954	205	186	1.8	0.9	1.7	8.0	8.8	1.0	794
Access to cable/satellite TV													
Have cable TV	1,149	459	84	955	217	209	3.0	1.7	2.0	10.6	11.5	1.0	1,331
Have satellite dish	1,154	373	109	1,050	177	218	1.4	3.2	2.0	7.5	9.6	1.4	97
Have neither[c]	889	379	35	899	261	160	2.3	1.7	2.2	11.0	13.9	2.3	572

NOTE: Responses are to the statements: "Altogether, on an average day, about how many hours would you say that you watch television? About how many of those hours are news reports or news shows?" "Now, let me ask you about your use of museums, zoos, and similar institutions. I am going to read you a short list of places and ask you to tell me how many times you visited each type of place during the last year, that is, the last 12 months. If you did not visit any given place, just say none. A natural history museum—how many times did you visit it during the last year? A zoo or an aquarium—how many times did you visit it during the last year? A science or technology museum—how many times did you visit it during the last year? A public library—how many times did you visit it during the last year?"; "During the last 12 months, did you borrow any books from the public library? (if yes):About how many books did you borrow during the last year?" "During the last 12 months, did you borrow any videotapes from the public library? (if yes):About how many videotapes did you borrow during the last year?" "Do you watch any television shows that focus primarily on science or nature? Which science or nature show do you watch most often? About how many times a month do you watch this show?"; and "On an average day, about how many hours would you say that you listen to a radio? About how many of those hours are news reports or news shows?"

[a] Respondents were classified as having a "high" level of science/mathematics education if they took nine or more high school and college science/math courses. They were classified as "middle" if they took six to eight such courses, and as "low" if they took five or fewer.

[b] The attentive public for science and technology combines the attentive public for new scientific discoveries and the attentive public for new inventions and technologies. Any individual who is not attentive to either of those issues but who is a member of the interested public for at least one of those issues is classified as a member of the interested public for science and technology. All other individuals are classified as members of the residual public for science and technology.

[c] This category includes 79 respondents who reported that they did not watch any television.

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations prepared for the National Science Foundation, Science Resources Studies Division.

See figures 7-18 and 7-19.

Appendix table 7-26.
Public's access to computers from work and home, by selected characteristics: 1983-97

Characteristic	1983	1985	1988	1990	1995	1997
			Percentages			
All adults						
No access	70	66	62	58	46	43
Access from work or home	27	28	29	30	33	34
Access from work and home	3	6	9	12	21	23
Male						
No access	68	62	59	55	41	42
Access from work or home	28	30	30	30	34	32
Access from work and home	4	8	11	15	25	26
Female						
No access	72	69	66	61	50	44
Access from work or home	26	26	28	31	33	36
Access from work and home	2	5	6	8	17	20
Less than high school graduate						
No access	94	87	92	85	80	79
Access from work or home	6	13	8	14	18	18
Access from work and home	0	0	0	1	2	3
High school graduate						
No access	66	65	58	55	42	40
Access from work or home	31	30	35	34	38	39
Access from work and home	3	5	7	11	20	21
Baccalaureate or higher degree						
No access	47	40	33	29	18	12
Access from work or home	45	43	41	41	36	38
Access from work and home	8	17	26	30	46	50
Attentive public for science and technology[a]						
No access	61	56	50	44	31	34
Access from work or home	29	33	35	31	31	36
Access from work and home	10	11	15	25	38	30
			Sample size			
All adults	631	2,005	2,041	2,033	2,006	2,000
Male	775	950	958	964	953	930
Female	856	1,054	1,084	1,070	1,053	1,070
Less than high school graduate	404	507	530	495	418	420
High school graduate	941	1,147	1,158	1,202	1,196	1188
Baccalaureate or higher degree	282	349	353	336	392	392
Attentive public for science and technology	208	235	233	229	195	288

NOTE: In 1985, 1988, 1990, 1995 and 1997, the question was worded, "Do you use a computer in your work? About how many hours do you personally use your work computer in a typical week? Do you presently have a home computer in your household? About how many hours do you personally use your home computer in a typical week?" In 1983, the question was worded, "Do you use computers or word processing equipment in your work?..."

[a] The attentive public for science and technology contains the attentive public for new scientific discoveries and the attentive public for new inventions and technologies.

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

See figures 7-20 and 8-24.

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Appendix table 7-27.

Public's access to and use of computers at home and work, by selected characteristics: 1997

(Percentages)

Characteristic	Use computer in work	Have computer at home	Computer at home & work	Computer at home or work	No computer	Home computer: Modem	Home computer: On-line service	Home computer: CD-ROM	Home computer: E-mail address	Home computer: Access WWW	Work computer: E-mail address	Work computer: Access WWW	Use (hours/year): Work computer	Use (hours/year): Home computer	Use (hours/year): On-line hrs/year
All adults	38	43	23	57	43	33	18	29	18	16	16	14	369	130	29
Sex															
Male	41	44	26	58	42	35	21	31	20	20	18	18	371	161	37
Female	35	41	20	56	44	33	15	26	15	13	14	11	368	102	22
Formal education															
Less than high school	6	19	3	21	79	13	1	8	6	5	1	2	31	51	4
High school graduate	39	42	21	60	40	31	17	29	17	14	12	11	390	119	26
Baccalaureate degree	67	67	47	87	13	54	35	49	31	32	40	36	695	237	60
Grad./professional degree	68	76	54	88	12	62	41	55	37	38	43	45	612	263	69
Science/math education[a]															
Low	22	29	12	40	60	20	9	17	8	7	5	5	221	71	12
Middle	51	53	32	72	28	42	23	38	25	22	22	18	439	162	31
High	64	68	44	88	12	56	37	51	36	36	38	35	709	257	74
Attentiveness to science and technology[b]															
Attentive public	42	54	30	66	34	47	26	40	30	30	23	23	465	225	55
Interested public	42	46	26	63	37	34	20	31	18	17	17	16	398	152	32
Residual public	31	34	18	48	52	26	13	22	13	10	12	9	301	69	16
Access to cable/satellite TV															
Have cable TV	41	46	25	61	39	36	20	32	20	18	17	15	401	143	32
Have satellite dish	39	45	21	63	37	33	17	31	18	19	12	10	308	134	39
Have neither[c]	30	35	17	47	53	24	12	21	12	11	12	13	306	97	20

WWW = World Wide Web

NOTE: Responses are to the statements: "Do you use a computer in your work? About how many hours do you personally use your work computer in a typical week? Do you have an e-mail address for use at work? Do you have access to the World Wide Web through your work computer? Do you presently have a home computer in your household? About how many hours do you personally use your home computer in a typical week? Do you have a CD-ROM reader in your home computer? Do you have a modem in your home computer? Do you presently subscribe to any network service like CompuServe, Prodigy, America Online, or any other dial-in-service? About how many hours a month do you use your dial-in or network service? Do you have an e-mail address that you use with your home computer? Do you ever access the World Wide Web through your home computer?"

[a] Respondents were classified as having a "high" level of science/mathematics education if they took nine or more high school and college science/math courses. They were classified as "middle" if they took six to eight such courses, and as "low" if they took five or fewer.

[b] The attentive public for science and technology combines the attentive public for new scientific discoveries and the attentive public for new inventions and technologies. Any individual who is not attentive to either of those issues but who is a member of the interested public for at least one of those issues is classified as a member of the interested public for science and technology. All other individuals are classified as members of the residual public for science and technology.

[c] This category includes 79 respondents who reported that they did not watch any television.

SOURCES: J.D. Miller and L. Kimmel, *Public Attitudes Toward Science and Technology, 1979-1997, Integrated Codebook* (Chicago: Chicago Academy of Sciences, International Center for the Advancement of Scientific Literacy, 1997); and unpublished tabulations.

Appendix table 8-1.

Uses of computers in the workplace: 1993

Application	Workers who use this application: Number (thousands)	Workers who use this application: Percentage
Analysis	13,018	25
Bookkeeping	13,236	26
Bulletin boards	4,315	8
Calendar scheduling	11,846	23
Communications	16,058	31
Computer-assisted design	3,856	8
Databases	17,556	34
Desktop publishing	5,933	12
Educational programs	4,689	9
E-mail	10,872	21
Games	2,930	6
Graphics	8,671	17
Inventory control	12,823	25
Invoicing	10,057	20
Learn to use	4,820	9
Programming	6,671	13
Sales	7,629	15
Spreadsheets	12,045	24
Telemarketing	1,656	3
Word processing	22,624	44
Other	9,841	19
Don't know	2,895	6
Total workers who use a computer	**51,106**	

SOURCE: U.S. Bureau of the Census, Current Population Survey, October 1993. Available from <<http://www.census.gov/population/socdemo/computer/compusea/text>>.

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Appendix table 8-2.

Index of real net information technologies capital stock in the private sector: 1960-95

	Office, computing, and accounting machinery	Communications equipment	All nonresidential durable equipment
1960	0.23	8.15	25.62
1961	0.24	9.27	26.18
1962	0.25	10.56	27.06
1963	0.29	11.56	28.12
1964	0.34	12.50	29.56
1965	0.40	13.69	31.67
1966	0.53	15.09	34.26
1967	0.65	16.46	36.44
1968	0.76	17.84	38.76
1969	0.93	19.64	41.32
1970	1.09	21.64	43.32
1971	1.28	23.25	45.08
1972	1.57	24.52	47.46
1973	1.90	26.43	50.92
1974	2.34	28.26	54.11
1975	2.64	29.63	55.89
1976	3.12	31.22	57.88
1977	3.78	34.23	60.81
1978	5.33	38.13	64.75
1979	7.57	43.01	68.95
1980	10.48	48.46	71.95
1981	14.25	53.71	74.76
1982	17.19	58.50	76.22
1983	22.87	62.70	77.86
1984	32.03	67.54	81.11
1985	41.88	72.67	84.45
1986	51.55	77.58	87.32
1987	59.61	81.59	89.63
1988	66.84	86.52	92.30
1989	75.82	90.75	95.03
1990	81.69	94.58	97.22
1991	87.31	97.21	98.39
1992	100.00	100.00	100.00
1993	119.03	102.20	102.72
1994	143.14	106.43	106.90
1995	178.09	112.78	111.89

NOTE: Index is chain-link index; values are expressed relative to 1992 dollars.

SOURCE: U.S. Bureau of Economic Analysis, *Survey of Current Business* (May 1997), table 4, pp. 82-84.

See figure 8-2.

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Appendix table 8-3.

Gross product by industry as a share of gross domestic product: 1959-94, selected years

(Percentages)

Industry	1959	1967	1977	1982	1987	1988	1989	1990	1991	1992	1993	1994
Goods, total	38.9	36.0	32.8	31.0	27.3	27.6	26.8	26.2	24.7	24.0	23.7	24.2
Agriculture, forestry, and fishing	4.0	3.0	2.7	2.4	1.9	1.8	1.9	1.9	1.7	1.8	1.6	1.7
Mining	2.5	1.8	2.7	4.6	1.9	2.0	1.8	2.0	1.7	1.5	1.4	1.3
Construction	4.7	4.7	4.6	4.0	4.6	4.6	4.5	4.3	3.9	3.7	3.7	3.9
Manufacturing	27.7	26.5	22.8	20.0	18.9	19.2	18.6	18.0	17.4	17.0	17.0	17.3
Services, total	48.8	49.8	51.9	53.9	59.1	59.7	59.6	59.8	61.0	61.3	61.6	62.0
Transportation and public utilities[a]	8.9	8.5	8.9	9.0	9.0	8.8	8.5	8.4	8.7	8.5	8.6	8.7
Wholesale trade	7.1	6.9	7.0	6.8	6.4	6.7	6.6	6.4	6.6	6.5	6.5	6.7
Retail trade	9.7	9.4	9.4	8.9	9.3	9.1	9.0	8.8	8.7	8.7	8.7	8.8
Finance, insurance, and real estate	13.6	14.1	14.0	15.6	17.7	17.7	17.7	17.8	18.3	18.4	18.5	18.4
Professional[b]	5.2	6.5	8.6	10.6	12.5	10.8	11.0	11.5	11.7	12.1	12.2	12.3
Personal[c]	3.4	3.5	3.1	3.1	3.4	3.5	3.4	3.6	3.5	3.6	3.5	3.6
Other[d]	0.9	0.9	0.8	0.8	0.9	3.2	3.7	3.6	3.4	3.5	3.5	3.6
Government	12.8	14.1	14.5	14.2	13.9	13.8	13.6	13.8	14.2	14.0	13.7	13.4

NOTE: Shares are based on current dollars.

[a] This includes communications.

[b] Professional services include business, health, legal, educational, social, and (through 1987) miscellaneous professional services.

[c] Personal services include hotels and lodging, personal, auto repair and services, miscellaneous repair, amusement and recreation, and private household services.

[d] Other services include motion pictures, membership organizations, and (after 1987) other.

SOURCE: U.S. Bureau of Economic Analysis, *Survey of Current Business* (August 1996), table 11.

See figures 8-6 and 8-7

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Appendix table 8-4.
U.S. employment by industrial sector: 1950-90, selected years
(Percentages)

Industry	1950	1960	1970	1980	1990
Total	100.0	100.0	100.0	100.0	100.0
Extractive	14.4	8.1	4.6	4.5	3.5
Agriculture	12.7	7.0	3.7	3.6	2.8
Mining	1.7	1.1	0.8	1.0	0.6
Transformative	33.9	35.9	33.0	29.6	25.6
Constructive	6.2	6.2	6.0	6.2	6.5
Utilities	1.4	1.4	1.1	1.2	1.1
Manufacturing	26.2	28.3	25.9	22.2	18.0
Food	2.7	3.1	1.9	1.9	1.6
Textiles	2.2	3.3	1.3	0.8	0.6
Metal	3.6	3.9	3.1	2.7	1.8
Machinery	3.7	7.5	5.1	5.2	3.8
Chemical	1.7	1.8	1.5	1.6	1.3
Miscellaneous manufacturing	12.3	8.7	12.9	10.0	8.9
Distributive services	22.4	21.9	22.4	21.0	20.6
Transportation	5.3	4.4	3.9	3.7	3.5
Communication	1.2	1.3	1.5	1.5	1.3
Wholesale	3.5	3.6	4.0	3.9	3.9
Retail	12.3	12.5	12.9	11.9	11.8
Producer services	4.8	6.6	8.2	10.5	14.0
Banking	1.1	1.6	2.2	2.6	2.9
Insurance	1.4	1.7	1.8	1.9	2.1
Real estate	1.0	1.0	1.0	1.6	1.8
Engineering	0.2	0.3	0.4	0.6	0.7
Accounting	0.2	0.3	0.4	0.5	0.5
Miscellaneous business services	0.6	1.2	1.8	2.6	4.9
Legal services	0.4	0.5	0.5	0.8	1.0
Social services	12.4	16.3	22.0	23.7	24.9
Medical, health services	1.1	1.4	2.4	2.3	4.3
Hospital	1.8	2.7	3.7	5.3	4.0
Education	3.8	5.4	8.5	8.3	7.9
Welfare, religious services	0.7	1.0	1.2	1.6	2.6
Nonprofit organization	0.3	0.4	0.4	0.5	0.4
Postal service	0.8	0.9	1.0	0.7	0.7
Government	3.7	4.3	4.5	4.7	4.8
Miscellaneous social services	0.1	0.2	0.3	0.4	0.2
Personal services	12.1	11.3	10.0	10.5	11.5
Domestic services	3.2	3.1	1.7	1.3	0.9
Hotel	1.0	1.0	1.0	1.1	1.5
Eating, drinking places	3.0	2.9	3.2	4.4	4.8
Repair services	1.7	1.4	1.4	1.3	1.4
Laundry	1.2	1.0	0.8	0.4	0.5
Barber, beauty shops	–	0.8	0.9	0.7	0.7
Entertainment	1.0	0.8	0.8	1.0	1.3
Miscellaneous personal services	1.2	0.4	0.3	0.3	0.4

NOTE: Details may not add to totals because of rounding.

SOURCE: M. Castells, *The Rise of the Network Society* (Cambridge, MA: Basil Blackwell, 1996).

See figure 8-8.

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Appendix table 8-5.
Workers who use a computer at work, by sector: 1993

Sector	Total employed in sector (thousands)	Workers in sector who use a computer	
		Number (thousands)	Percentage
Government	5,927	4,137	70
All industries	118,400	51,106	43
Agriculture	3,140	435	14
Mining	689	307	45
Construction	7,567	1,182	16
Manufacturing, total	19,605	8,178	42
Food	1,776	532	30
Tobacco	52	25	48
Apparel	970	143	15
Textiles	664	177	27
Leather and leather products	107	24	22
Lumber and wood	841	114	14
Furniture	665	161	24
Paper and allied products	740	339	46
Printing and publishing	1,705	857	50
Chemicals	1,220	729	60
Petroleum and coal	145	88	61
Rubber and plastics	791	293	37
Stone, clay, and glass	568	165	29
Primary metals	653	217	33
Fabricated metals	1,290	442	34
Non-electric machinery	2,238	1,233	55
Electric machinery	1,689	950	56
Motor vehicles	1,120	428	38
Aircraft	502	335	67
Other transportation	624	376	60
Photo equipment	680	406	60
Toys and sporting goods	128	44	34
Miscellaneous manufactures	437	100	23
Services, total	81,473	36,867	45
Transportation	5,410	1,866	34
Communications	1,637	1,283	78
Utilities	1,501	807	54
Wholesale trade	4,531	2,226	49
Retail trade	18,706	5,837	31
Banking and finance	3,417	2,888	85
Insurance and real estate	4,561	3,094	68
Professional services	31,020	16,515	53
Personal services	10,690	2,351	22
Business services	5,038	2,646	53

SOURCE: U.S. Bureau of the Census, Current Population Survey, October 1993. Available from <<http://www.census.gov/population/socdemo/computer/compusea/text>>.

See figure 8-9.

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Appendix table 8-6.

Index of information technologies investments, by industry: 1991-92

Industry	Industry's share of GDP, 1992 (%)	Industry's IT investments 1991 ($ billion)	Industry's share of IT investments (%)	Investment Index
Manufacturing	17.0	25.30	16.6	0.98
Transportation	3.1	3.80	2.5	0.81
Communications	2.6	21.10	13.9	5.35
Utilities	2.8	8.00	5.3	1.89
Wholesale trade	6.5	17.00	11.2	1.72
Retail trade	8.7	17.90	11.8	1.36
Finance, insurance, and real estate	18.4	38.70	25.4	1.38
Professional and personal services	19.2	20.30	13.3	0.69

IT = information technologies

NOTE: Investment Index equals industry's share of IT investments divided by industry's share of GDP. An index of 1.00 reflects no over- or under-investing in IT relative to the size of the industry.

SOURCES: Industry investments from National Research Council, *Information Technology in the Service Society* (Washington, DC: National Academy Press, 1994), p. 2; share of GDP from U.S. Bureau of Economic Analysis, *Survey of Current Business* (August 1996), p. 137.

See figure 8-10.

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Appendix table 8-7.
Technology in public schools: 1992-95

Technology	Number				Percentage of total	
	1992	1993	1994	1995	1992	1995
Schools with interactive videodisk players[a]	6,502	11,729	19,189	23,112	8	27
Elementary	2,921	5,986	10,043	12,326	6	24
Junior high	1,258	2,386	3,844	4,672	10	34
Senior high	2,106	3,129	5,026	5,805	14	34
Students represented (1,000)	5,781	9,064	13,434	16,060	14	36
Schools with modems[a]	13,597	18,471	24,277	28,275	16	34
Elementary	5,831	8,492	11,679	14,782	11	29
Junior high	2,608	3,431	4,531	5,393	20	39
Senior high	5,001	6,371	7,853	8,620	30	51
Students represented (1,000)	10,717	13,382	16,476	19,326	25	43
Schools with networks[a]	4,184	11,657	19,272	23,402	5	28
Elementary	1,583	4,683	8,477	11,155	3	22
Junior high	776	2,030	3,611	4,425	6	32
Senior high	1,736	4,895	7,104	8,042	10	48
Students represented (1,000)	3,754	8,043	12,713	15,160	9	34
Schools with CD-ROMs[a]	5,706	11,021	24,526	31,501	7	37
Elementary	1,897	4,457	11,794	16,816	4	33
Junior high	1,231	2,326	4,874	6,170	9	45
Senior high	2,543	4,168	7,724	9,063	15	64
Students represented (1,000)	5,298	8,534	15,576	19,501	12	44
Schools with satellite dishes[a]	1,129	8,812	12,580	14,290	1	17
Elementary	351	2,988	4,269	5,154	1	10
Junior high	166	1,503	2,497	3,004	1	22
Senior high	606	4,292	5,770	6,263	4	37
Students represented (1,000)	1,906	4,668	6,740	7,946	4	18
Schools with cable[a]	NA	47,745	58,652	62,593	NA	74
Elementary	NA	27,923	35,325	37,730	NA	73
Junior high	NA	9,266	10,696	11,416	NA	83
Senior high	NA	10,296	12,198	13,089	NA	78
Students represented (1,000)	NA	27,324	33,510	35,770	NA	80

NA = not available

NOTE: Elementary includes K-12, preschool, preschool through 8, K-6, and K-8. Junior high includes schools with grade spans of 4-6, 7-8, and 7-9. Senior high includes 7-12, 9-12, 10-12, vocational, technical, and alternative high schools.

[a] Includes schools for special education and adult education not shown separately.

SOURCE: U.S. Bureau of the Census, *Statistical Abstract of the United States 1996*, table 264 (Washington, DC: U.S. Government Printing Office, 1996); data based on surveys conducted by Quality Education Data, Inc.

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Appendix table 8-8.

Student use of computers at home and at school, by sex, race/ethnicity, and household income: 1984 and 1993

(Percentages)

Characteristic	1984 total	1993					
		Total	Pre-K and K	Grades 1-8	Grades 9-12	1st to 4th year of college	5th or later year college
Computer use at school							
Total	27.3	59.0	26.2	68.9	58.2	55.2	52.1
Sex							
Male	29.0	59.4	25.9	69.5	56.5	57.5	56.7
Female	25.5	58.7	26.5	68.4	60.0	53.3	47.8
Race/ethnicity							
White	30.0	61.6	29.4	73.7	59.9	54.9	59.8
Black	16.8	51.5	16.5	56.5	54.5	56.9	57.9
Hispanic	18.6	52.3	19.2	58.4	54.1	51.9	53.7
Other	28.6	59.0	23.5	65.7	57.3	60.9	69.4
Household income							
Less than $5,000	18.7	51.2	19.6	55.0	50.6	61.7	66.7
$5,000 to $9,999	21.0	53.3	24.4	60.3	51.9	53.9	56.2
$10,000 to $14,999	22.4	56.4	20.1	64.7	56.7	50.7	76.1
$15,000 to $19,999	25.9	58.1	23.8	67.5	57.4	51.2	58.5
$20,000 to $24,999	26.7	56.4	23.7	64.3	53.0	57.4	52.4
$25,000 to $29,999	30.5	60.0	28.0	70.1	60.3	51.5	58.0
$30,000 to $34,999	30.5	59.1	23.7	69.6	59.7	51.7	45.3
$35,000 to $39,999	32.3	60.7	27.1	72.1	61.7	49.2	47.9
$40,000 to $49,999	32.8	59.3	28.5	70.3	57.2	53.9	48.6
$50,000 to $74,999	35.5	62.6	28.6	75.6	61.5	57.4	44.2
$75,000 or more	36.0	64.6	33.5	78.7	62.5	60.9	47.7
Institution type							
Public	27.4	60.2	30.1	68.6	58.1	53.9	54.1
Private	26.5	52.1	18.7	72.5	60.7	60.7	48.0
Computer use at home							
Total	11.5	27.0	15.6	24.7	28.7	32.8	52.6
Sex							
Male	14.0	27.4	15.1	24.8	28.2	36.6	56.1
Female	9.0	26.6	16.1	24.6	29.2	29.7	49.5
Race/ethnicity							
White	13.7	32.8	19.4	31.4	35.9	36.0	53.6
Black	4.9	10.9	4.2	9.0	10.4	19.4	48.1
Hispanic	3.6	10.4	5.7	7.5	9.8	22.0	52.2
Other	9.0	28.7	17.0	23.2	37.0	33.0	47.1
Household income							
Less than $5,000	2.9	9.7	1.1	4.1	6.8	25.6	45.2
$5,000 to $9,999	3.2	8.0	0.9	4.5	5.3	21.3	45.6
$10,000 to $14,999	5.0	11.4	4.6	6.4	8.7	29.8	50.0
$15,000 to $19,999	7.5	15.1	6.9	10.9	14.1	28.9	43.0
$20,000 to $24,999	9.9	16.8	7.4	13.1	17.9	27.7	49.6
$25,000 to $29,999	12.8	21.1	12.3	19.3	22.0	26.1	47.0
$30,000 to $34,999	15.8	24.1	18.7	20.5	29.1	26.4	44.4
$35,000 to $39,999	19.4	27.1	13.0	26.3	28.1	32.7	52.7
$40,000 to $49,999	20.4	32.2	21.6	32.9	33.9	32.5	45.9
$50,000 to $74,999	24.2	43.0	25.5	45.3	46.4	40.1	58.2
$75,000 or more	22.1	56.1	38.2	62.3	61.0	47.0	64.7
Institution type							
Public	11.2	25.3	12.1	23.0	27.2	31.9	50.0
Private	13.8	37.4	22.4	41.5	47.2	36.9	57.7

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Appendix table 8-8.

Student use of computers at home and at school, by sex, race/ethnicity, and household income: 1984 and 1993

(Percentages)

Characteristic	1984 total	1993 Total	1993 Pre-K and K	1993 Grades 1-8	1993 Grades 9-12	1993 1st to 4th year of college	1993 5th or later year of college
Computer use at home for school work							
Total	4.6	14.9	0.6	10.8	20.9	23.1	36.6
Sex							
Male	5.9	14.8	0.9	10.1	20.5	26.3	40.3
Female	3.3	15.0	0.4	11.5	21.4	20.5	33.2
Race/ethnicity							
White	5.4	18.2	0.8	13.8	26.5	25.7	37.8
Black	2.3	5.7	NA	4.0	6.9	11.5	30.1
Hispanic	1.4	5.6	NA	2.9	6.7	15.9	36.8
Other	3.8	16.0	1.1	9.3	27.0	23.7	29.2
Household income							
Less than $5,000	1.0	6.7	NA	2.5	4.0	18.7	36.0
$5,000 to $9,999	1.5	4.8	NA	1.1	3.6	16.1	35.5
$10,000 to $14,999	1.9	7.3	NA	2.6	5.6	25.9	34.6
$15,000 to $19,999	3.0	8.6	0.4	4.7	10.8	18.7	31.0
$20,000 to $24,999	3.1	9.8	0.7	5.1	12.6	22.9	35.0
$25,000 to $29,999	5.1	10.4	1.1	6.3	13.4	19.5	34.9
$30,000 to $34,999	4.9	13.0	0.8	8.1	21.9	18.0	35.1
$35,000 to $39,999	7.1	15.4	0.8	12.4	21.0	22.6	37.2
$40,000 to $49,999	9.2	17.1	1.1	14.7	24.2	22.2	32.1
$50,000 to $74,999	11.5	23.2	1.0	19.7	35.0	27.0	38.2
$75,000 or more	9.8	30.4	0.8	29.4	45.2	30.6	41.5
Institution type							
Public	4.5	14.2	0.5	10.1	19.8	22.7	34.7
Private	5.4	18.8	1.0	17.8	35.4	24.8	40.1

Pre-K and K = prekindergarten and kindergarten

SOURCE: U.S. Bureau of the Census, *Statistical Abstract of the United States, 1996*, table 263 (Washington, DC: U.S. Government Printing Office, 1996)

See figures 8-19 and 8-21.

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Appendix table 8-9.

Adult use of computers at home, school, and work: 1993

(Percentages)

Characteristic	Uses computer anywhere	Has computer at home	Has computer at home and uses computer at home	Enrolled in school and uses computer at school	Has a job and uses computer at work
Age					
Persons over 18	36.0	25.6	65.6	53.8	45.8
18-21 years	45.9	30.4	62.5	62.3	25.8
22-24 years	43.5	25.4	68.9	53.1	42.1
25-34 years	44.4	25.3	73.8	45.2	49.1
35-44 years	46.7	34.2	68.4	43.0	50.8
45-54 years	43.8	34.4	64.0	40.4	49.8
55-64 years	24.2	19.9	55.9	31.9	37.3
65+ years	4.9	8.4	41.2	36.0	20.3
Race					
White	37.5	26.9	66.7	53.1	47.1
Black	25.0	13.8	56.8	54.8	36.1
Other	35.6	31.3	55.8	60.3	42.3
Hispanic origin					
Hispanic	22.0	12.9	61.3	50.0	29.3
Not Hispanic	37.2	26.7	65.8	54.1	47.2
Sex					
Male	36.2	27.1	70.0	55.9	40.3
Female	35.8	24.3	61.1	51.9	52.4
Marital status					
Married	37.5	29.4	65.3	40.5	48.2
Single	42.5	25.3	68.8	58.9	41.2
Divorced/widowed	23.7	14.0	61.3	45.8	43.1
Uses computer					
At work	100.0	43.2	79.4	48.9	100.0
At home	100.0	100.0	NA	55.9	73.0
Household type					
Married couple	38.6	30.4	64.4	54.2	46.8
Female householder	29.2	14.1	65.0	51.4	45.9
Male householder	33.8	20.0	76.5	55.4	41.2
Region					
Northeast	34.3	25.6	62.2	56.4	46.0
Midwest	37.2	25.1	64.9	30.0	45.8
South	33.8	22.1	65.3	51.8	44.3
West	39.6	31.8	69.3	47.3	48.2
Educational attainment					
Less than 9th grade	1.5	4.5	12.7	31.1	4.0
9th-11th grade	9.8	8.1	41.8	46.6	13.0
High school graduate	25.1	16.7	49.3	51.7	34.2
Some college/associate's degree	50.5	33.1	67.9	56.3	52.6
Bachelor's +	63.4	48.7	76.9	50.5	69.1
Employment					
Employed	49.8	30.8	66.5	43.6	43.2
Full time	51.4	30.6	69.4	37.6	49.6
Part time	41.9	31.4	68.0	57.5	28.1
Unemployed	17.5	22.1	67.0	51.0	NA
Not in labor force	11.5	16.1	52.1	62.9	NA
School enrollment					
Not enrolled	32.8	23.9	63.6	NA	45.5
Below college	47.9	22.0	71.8	46.3	11.9
College	74.7	47.4	77.7	54.6	53.0

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Appendix table 8-9.

Adult use of computers at home, school, and work: 1993

(Percentages)

Characteristic	Uses computer anywhere	Has computer at home	Has computer at home and uses computer at home	Enrolled in school and uses computer at school	Has a job and uses computer at work
Family income					
Less than $10,000	11.4	6.8	68.6	53.6	18.3
$10,000-$14,999	15.2	8.4	64.8	55.3	23.7
$15,000-$19,999	23.0	12.5	62.4	50.9	31.7
$20,000-$24,999	27.7	15.3	62.3	56.6	36.0
$25,000-$34,999	36.5	21.2	64.3	50.9	42.8
$35,000-$49,999	46.3	31.3	55.4	51.0	50.6
$50,000-$74,999	60.3	45.9	67.1	54.4	61.5
$75,000 and over	65.4	61.7	68.0	58.8	67.0
Income not reported	24.4	20.2	57.2	53.3	39.5
Household size					
1-3 persons	33.7	21.2	69.6	51.9	47.5
4-5 persons	43.1	35.8	62.1	56.0	45.0
6-7 persons	30.4	28.6	52.3	56.2	33.7
8+ persons	17.6	22.1	48.3	49.8	19.5
Occupation					
Management and professional	69.6	47.9	77.0	46.7	67.7
Technical, sales, administration	63.6	31.6	69.2	50.7	65.5
Service	22.4	18.6	54.9	53.5	14.7
Precision, production, craft	26.0	21.6	56.8	44.0	23.2
Operators, labor	18.8	15.2	51.9	47.0	14.9
Farm, forest, fish	14.7	16.7	59.5	62.5	8.5
Never work/NILF/AF	10.7	15.4	50.9	61.8	NA
Industry					
Agriculture	19.1	19.9	64.9	51.3	13.5
Mining	44.7	30.7	64.0	(B)	46.1
Construction	20.2	21.4	57.3	49.1	16.8
Manufacturing	43.0	27.3	69.4	48.6	44.0
Transportation, communications, utilities	48.8	29.9	63.6	46.5	49.4
Wholesale/retail	40.8	25.4	61.8	53.1	37.0
Finance, insurance	74.6	36.0	72.4	38.4	79.3
Services	51.2	35.2	72.6	51.2	48.0
Forest/fisheries	36.1	28.8	(B)	(B)	35.2
Public administrator	70.6	34.1	74.0	32.2	73.7
Never work/NILF/AF	10.7	15.4	50.9	61.8	NA

AF = armed forces; (B) = less than 75,000 persons or 50 sample cases; NA = not applicable; NILF = not in labor force

NOTES: Persons of Hispanic origin may be of any race. The term "uses computer anywhere" means that the individual uses computer at home, at school, and/or at work; the term "with computer at home" means that there is a computer in the household.

SOURCE: U.S. Bureau of the Census, Current Population Survey, October 1993. Available from <<http://www.census.gov/population/socdemo/computer/compusea/text>>.

See figures 8-23 and 8-25.

Appendix table 8-10.

Commercial banks output per employee: 1967-95

Year	Index	Year	Index
1967	71.2	1981	78.7
1968	72.5	1982	81.0
1969	71.5	1983	87.6
1970	72.3	1984	90.7
1971	75.1	1985	94.6
1972	76.9	1986	97.0
1973	81.7	1987	100.0
1974	76.9	1988	101.4
1975	77.2	1989	99.6
1976	81.4	1990	102.6
1977	85.9	1991	104.5
1978	86.8	1992	106.4
1979	84.5	1993	115.5
1980	78.8	1994	115.8
		1995	121.7

NOTES: Commercial banks are Standard Industrial Classification code 602. Industry Productivity Index: 1987 = 100.

SOURCE: U.S. Bureau of Labor Statistics, Industry Productivity Index, <<http://stats.bls.gov/cgi-bin/dsrv>> (data extracted July 1997).

See figure 8-12. *Science & Engineering Indicators – 1998*

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Appendix B
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